TOPICS OF THE MONTH

Chemical engineers in the New World

A RECENT study of future technical manpower requirements of the U.S. chemical industry made by the American Manufacturing Chemists' Association shows that by 1965 there may be a 65% shortage—possibly 84,000 out of some 160,000 men required. This is bound to result in an added attraction to technologists and scientists, including chemical engineers, from other countries, and because of the proportionately high British immigration quota permitted under the Walter-McCarran Act, the annual loss of trained men from the United Kingdom could be particularly high. A similar situation will probably also arise from the continued expansion of the Canadian chemical industry.

To many chemical engineers, the United States in particular has a strong appeal, not fully realised by some managements and members of other professions, and if the universities and new technical colleges of Britain are not to become virtual training grounds for North American industry, this situation should be examined now, so that a suitable compromise can be worked out, to the benefit of all concerned.

Some observations on this subject by a British chemical engineer who recently went to work in North America are published in the June issue of our associate journal, *Manufacturing Chemist*. In addition to a common language and the desire for fresh experiences, two important factors in the strong appeal of U.S. industry to the British chemical engineer, he believes, are a belief in U.S. technical superiority and a belief in higher pay in the U.S. Perhaps of even greater long-term significance are the factors of recognition of the profession of chemical engineering and the spur to ambition offered by the opportunities for considerable responsibility at an early stage. It is pointed out that the highest positions in a variety of industries are open to chemical engineers of maturity and experience, while it is quite common to find young men confidently in charge of large operations that would terrify some European boards of directors.

Apart from the obvious need in this particular case for more organisations in the United Kingdom to offer increased opportunities both of a functional and an administrative nature to chemical engineers, the author of the article suggests a compromise solution for the general trend towards the New World on the part of European chemical engineers. Engineers would be encouraged to spend several years in North America and then would be induced to return—which, of course, presupposes suitable opportunities open to men with advanced experience and know-how to persuade them to return. If this were possible it would be of great benefit to individual organisations and the chemical industry as a whole.

Focus on plastics

IN this issue we feature some of the latest applications of plastics as materials of construction for chemical plant. Certain plastics materials have now become as familiar to chemical engineers, in name if not in actual knowledge and experience of using them, as some of the better-known metals, yet it is not so long ago that the materials so casually referred to as PTFE, PVC, polythene etc. were unfamiliar, unfathomable substances with long, unpronouncable names. The last word in plastics for chemical plant construction has by no means been said and we shall encounter many new chemical engineering applications of the established plastics, as well as many completely new plastics with the necessary properties of chemical resistance, strength and ease of fabrication for this purpose.

This month the biggest array of plastic products, materials and equipment ever assembled in Britain will appear at Olympia, London, where the British Plastics Exhibition and Convention is being held from July 10 to 20. The Exhibition includes developments from every branch of the British industry and from Belgium, France, Germany, Holland, Italy, Sweden, Switzerland and the United States. Preliminary information which has been released concerning the exhibits and the technical meetings suggests that some interesting new ideas will come to light at this year's event and that there will be a great deal to attract all who are concerned with the manufacture, processing or uses of plastics.

Particulars of the Exhibition and Convention can be obtained from: The Exhibition Manager, British Plastics, Dorset House, Stamford Street, London, S.E.1.

Fuels from air and water

WITH the advance of atomic energy for supplying power to large, static industrial units we shall still have a demand for fuels that can be carried and used by mobile units such as ships, aircraft and road vehicles. Shall we ever find a substitute for the coal, diesel oil or petrol oil that serves this need at present? Mr. T. M. Fry, of the United Kingdom Atomic Energy Authority, thinks that we shall, and that in possibly 20, probably 30 or 40 years' time, liquids for this purpose will be synthesised from the very simplest raw materials, using water and perhaps air.

This prediction followed a talk on nuclear reactors given at a meeting at Birmingham on June 15, in which the difficulty of capital charges for nuclear power units of anything less than the largest size was mentioned. The costs would come down, Mr. Fry said; it was simply a case of choosing the right reactor for the job. But it is probably true that the biggest nuclear stations will produce most cheaply.

Instrument technology and scientific progress

ONE of the great puzzles of the biochemists for the past century has been the way in which nature can synthesise carbohydrates from carbon dioxide and water in sunlight with the aid of chlorophyll. The problem has just been solved by Prof. M. Calvin in the University of California with the help of chromatography and radio-active carbon as a tracer atom. These have enabled him to take a series of snapshots at short intervals of the sequence of events. The synthesis proceeds by means of a complex cycle of reactions, one of nature's favourite dodges, in which carrier molecules pass through a cycle of changes each with its own catalyst, which would not be possible in isolation. Carbon dioxide enters the cycle at one point, reduction takes place at another, made possible by the radiant energy absorbed by the chlorophyll, and during a complex series of rearrangements of sugar molecules, sucrose passes out of the cycle while the carrier molecules continue to circulate. The cycle has to be repeated six times for each hexose molecule it produces. The necessary free energy is supplied at appropriate points by the transfer of rich energy bonds from adenosine triphosphate (ATP) to the circulating molecules, the ATP being reformed at the expense of degradative actions which are taking place simultaneously. This transfer of rich energy bonds from ATP is the key to the supply of the free energy required for the synthesis of the larger molecules produced in microbial metabolism.

This lucid exposition of one of the latest advances in biochemistry was given by Sir Harold Hartley, G.C.V.O., F.R.S., in an address which he gave to the Society of Instrument Technology as the Society's new president. Sir Harold, who is also a past-president of the Institution of Chemical Engineers, showed his clear grasp of scientific history by recalling the contribution of instruments, particularly measuring instruments, to great discoveries in all branches of science. By the beginning of the 19th century measurement had become an established technique, and it dominated the progress of the physical sciences. The rapid advances of the new science of electricity were associated with the work of Ampere, Faraday, Ohm and Kirchhoff and the new techniques of measurement that they devised. In optics, major advances came from measurement in polarimetry, spectrum analysis and interferometry. The progress of chemistry was dependent largely on accurate methods of analysing organic compounds.

New discoveries of measurement: *x*-rays, the cloud chamber, the Geiger counter, the mass spectrometer, the ultracentrifuger, radioactive tracer atoms, chromatography and many electronic devices, together with the extension of the fields of investigations into low and high temperatures and pressures, have enabled us to penetrate much more deeply into nature's secrets. The discoveries resulting from them are revealing a new picture, not of the simplicity but of the amazing complexity of nature, which seems to render any simplified general view in terms of today's concepts almost unthinkable. On the one hand we see the complexities revealed in the new types of particles and the families of mesons, and on the other the complexities of the living process, as in the example quoted above.

Sir Harold recalled that G. N. Lewis, 'who did more for chemical thermodynamics than any man but Willard Gibbs,' used to ask 'Does nature cheat in the game of entropy? Does she obey her own laws of thermodynamics?' The presumption was that she does obey, though it was difficult to see how she does it, but now we know. It is possible to see the reasons underlying the methods which nature has adopted in the long course of evolution. She has broken down each operation into stages, each of which involves a relatively small activation energy and therefore with a catalyst can proceed fast at ordinary temperatures. Equally from a thermodynamic aspect each involves only a conveniently small free energy change of the order of 10 to 15 Kcal., which can be provided by her interlocking mechanisms, if the mechanical analogy is not interpreted too literally.

Calcium nitrate produced by new process

CONSIDERABLE economies are claimed for a method for the continuous evaporation of calcium nitrate solutions, developed in Holland at the laboratories of Werkspoor N.V., which is claimed to have certain advantages over the conventional batchwise evaporation process. The production of calcium nitrate is usually coupled with the production of ammonia and nitric acid, the latter being derived from ammonia by oxidation. The evaporation process has invariably been carried out batchwise and largely in single effect because both the boiling plant and the viscosity of calcium nitrate solutions rise very considerably during evaporation.

With the new process, however, it is possible to carry out evaporation in two stages, followed by flash evaporation. A saving in steam consumption of 0.5 kg. per kg. of evaporated water was achieved, and regulation of the process is simplified, thus reducing manpower requirements. Moreover, there is less danger of a breakdown, *e.g.* on account of solidification of the product in the cooled lines, etc.

The highly satisfactory heat economy is achieved by the special design of the evaporators, in which the space containing the liquid is sub-divided into compartments by means of partitions. The solution to be evaporated passes through these compartments in a given sequence, causing its concentration and thus also its boiling point and viscosity to increase stepwise.

Neoprene lines gas scrubber

AN original application of neoprene as a lining for a hot fumes scrubber has recently been reported in the United States, where the Lithium Corporation of America, at their new Bessemer City plant, had previously tried several costly stainless alloys and two kinds of organic coatings, all of which were found to be short-lived.

The scrubber handles combustion gases from the

roasting kiln where the lithium ores are processed and where the gases pick up ore dust and acid fumes which have to be removed before the gas can be discharged from the stack. Coming from the kiln, the gas is precooled to about 140°F. and then enters the bottom of the scrubber where sulphur trioxide and dust are knocked down with 450-p.s.i. water sprays.

Abrasive ore dust in the acid fumes cut the protective oxide film from stainless steel, causing failure of several scrubbers in a matter of months. Resin linings proved equally unsuccessful. The coated fan and stainless-steel ductwork above the scrubber tower also were rapidly corroded. Within six months four or five fans failed.

A neoprene lining was applied and is reported to have given long service. Not only does it eliminate shutdown but, since the lining adequately resists the hot acid and abrasive dust, inexpensive mild steel can be used for the parts it covers.

A 'National Anti-corrosion Week' for Britain

THE growing awareness of the need to conserve material resources is one of the most heartening features of the contemporary industrial scene. Economy of utilisation is the dominant theme of new processes and new industrial undertaking. The far-seeing technologist and industrialist no longer think in terms of inexhaustible natural resources.

One important proof of this necessary new attitude is the attention now paid to the prevention of corrosion —a subject which has long ago forced itself upon the attention of the chemical engineer because the equipment he designs so often has to handle highly corrosive substances. Whether for this purpose or to counter the countless insidious and costly forms of corrosion found more generally in industry, the world's anti-corrosion armoury now boasts a versatile range of weapons.

The pressing need is to get industry to use them, and here our associate journal *Corrosion Technology* has been doing some commendable work. For over three years, with mounting success, it has preached the gospel of corrosion prevention, and eminent authorities have praised its enterprise. Its efforts will reach a new peak with the Corrosion Exhibition and Convention which will be the principal features of 'National Anti-corrosion Week,' to be sponsored by *Corrosion Technology* from October 14 to 18 this year. This includes an attractive programme of events which should do much to focus attention on a vital subject which is still not receiving enough attention.

There will be a two-day convention at the Central Hall, Westminster, at which the broad theme will be the economic and technical consequences of corrosion and the means available for its prevention and control. A number of distinguished speakers will present papers at this. The convention will be supported by a three-day exhibition of anti-corrosion methods, materials and equipment—the first full-scale exhibition of its kind to be held in Britain. From all angles, these events should be well worth the support of industry and, as our virile associate journal points out, the slogan for this eventful week may well be 'Coats off to Corrosion.'

Further news of 'National Anti-corrosion Week' will be published in CHEMICAL & PROCESS ENGINEERING in due course; meanwhile details of the programme can be obtained from *Corrosion Technology*, Stratford House, 9 Eden Street, London, N.W.1.

Chemical engineering in chocolate manufacture

A TRICKY process control problem—ensuring a steady cooling and crystallisation of the fat during the manufacture of chocolate slabs—has been achieved in an American chocolate factory by the use of a novel heat transfer and automatic control unit. The 'tempering' process which gives the chocolate a fine and uniform crystal formation is a complex one and the product has to be rapidly cooled to the desired temperature and a uniform crystal formation obtained. Sheen, texture and 'sharp snap' are qualities sought in the chocolate, and at the Klein Chocolate Co., Elizabethtown, Pennsylvania, they obtain these by using series-connected heat exchangers of 'scraped-surface' design, and with these is associated a highly sensitive multiple control system which continually adjusts the flow of constant-temperature cooling water in response to minute changes in product temperature.

As described in *Food Engineering* of March 1957 by J. C. Musser and D. Lineberry, the control system consists of a temperature transmitter, controller, receiving-recorder, and an air-operated diaphragm valve. It is stated that, in general, control of heat transfer is materially simplified by the exchanger's internal design, which provides a high ratio of surface to volume of material in process. Feed enters the machine through a passage formed by a rotating shaft and a heat-transfer tube, and material is rapidly dispersed in passing through the annulus, which provides for rapid cooling to a uniform temperature and crystal size. Furthermore, spiral flow of coolant promotes a high jacket velocity and turbulence that boost heat transfer.

These factors permit high throughput with relatively small equipment. For example, a unit handling 2,500 lb./hr. of chocolate occupies a space of only 15 ft. × 8 ft.

Reorganisation of a heavy chemicals firm

A YOUNG man saw an opportunity in the field of heavy chemicals and, by his own efforts, in a remarkably short time built up a flourishing concern with connections at home and abroad. He converted his business into a private limited company in 1902 and continued to prosper until his death 30 years later, when he was succeeded by his nephew. This nephew continued the business until he in turn died, eight years ago, and the company was converted into a public company, which today manufactures heavy chemicals at five works in different parts of the country, and with 30% of its output exported. The capital employed is approximately £3½ million, the number of employees being about 800.

The directors of the new public company were at once faced with the necessity for a radical change in

outlook. Hitherto their function had been to advise and carry out the policy of one man to whom alone they were responsible, and who was ultimately responsible only to himself. Overnight they became accountable to a large body of shareholders and, in addition, had to shoulder the wider responsibilities that existence as a public company entails.

This was the situation that faced the firm of Brotherton & Co. Ltd. as outlined at a recent address to the British Institute of Management by the company's financial director, Mr. W. F. Dunnett. He described how a new structure was evolved, the major features being that the deputy chairman functions as the co-ordinating and chief executive director; the company's four divisions—commercial, financial, production, research and development—are, in each case, directed and controlled by an executive director, with no other functional responsibility, while under these four executive directors there have been established four strong balanced structures: commercial, financial (including administration), production and research and development. On the production side, it is interesting to note that for the first time the entire production function and its ancillary services were conceived as being a single unit within the larger structure of the company. The major organisational change, which called for heavy recruitment, was that of the central engineering department. A chief engineer and a number of specialist engineers under him were recruited. The expansion was designed to permit the company to obtain the full benefits of facilities and capacity for handling projects efficiently; and of preventive maintenance methods, including work study, to keep plant and buildings in sound condition at minimum cost.

For research and development the major organisational change consisted of combining the development function with that of pure research, and placing the unit, which hitherto had operated to some degree in a vacuum and with its efforts diffused, under the control of a technical director. The internal structure of three separate sections, handling respectively (*a*) development, (*b*) research on new products and (*c*) process research and analytical chemistry, established the division's activities on a sound basis under closely co-ordinated control.

This streamlining of the company's organisation, according to Mr. Dunnett, brought about a number of advantages. Among these were that no one man has to carry the burden of the final responsibility for formulating and implementing policy; the four divisional directors are relieved of day-to-day functional activities and are able to concentrate on larger issues; each executive clearly knows and accepts his responsibility to his director and colleagues and the function he has to fulfil in implementing that responsibility; functional activities are carried out quicker and without confusion or waste of effort; and routine paper work has been minimised.

This well-integrated organisation of a company whose success in the heavy chemicals field is well known might well serve as an inspiration to others.

Automation in the chemical industry

DESPITE the relative facility of installation, chemical plants with complete automation are still very rare, and cited as a curiosity rather than as an accepted and proven convenience. Some of the reasons for the slow acceptance of automation in the chemical industry were discussed in a recent lecture by Ing. B. Orsoni at the Polytechnic of Milan, Italy.

He said that from a strictly technical point of view it was relatively easy to apply automation in chemical plant, where it could be used to control a complete process from the raw materials to the final product. However, the plants being planned today by progressive chemical engineers do not provide for complete automation, but simply for the use of certain automatic devices. The application of automation in the chemical industry is not advancing as widely or as rapidly as would be expected from the purely functional aspect.

The reason, according to Orsoni, is that the cost of chemical plant is extremely high in relation to the value of production and the cost of personnel. Furthermore, in an industry that is developing so rapidly, the expenses of documentation, research, patents etc. are also very high.

Automation therefore reduces the cost of personnel, which is relatively modest, but increases the cost of plant, already heavy, to anything from 15% to 35% above that of normal plant.

On the other hand, there are various intrinsic advantages in automation. It permits the operation of processes according to a strictly predetermined programme, independent of human error. It is possible to obtain greater precision, to avoid human negligence, and to increase yields.

What factors are likely to favour the wider introduction of automation in the chemical industry? Orsoni suggests first the reduction in cost of the apparatus for automatic control, which would in turn follow from its wider use. There is also scope for the development of more reliable, more efficient and less expensive equipment.

The progressive rise in salaries throughout the world and the universal shortage of good technologists will also weigh the balance in favour of automation. Finally, there must be a wider knowledge and appreciation of the advantages offered by its adoption.

In this last respect we still have a long way to go, particularly in Europe, where there is a tendency for chemical plants to be planned without an adequate understanding of physics and electronics. In spite of all these impediments, we may expect a steady diffusion of automatic control instruments throughout the industry, and eventually completely automatic plants.

Orsoni summarised these views by saying that 'automation in the chemical industry is a method and not a principle. It is neither a Utopia nor a danger, but simply an aspect of straightforward progress towards a higher standard of living.' His lecture has been published in *La Chimica e l'Industria* (1957, **34**, (4), April, 318).

PLASTICS
as Materials of Construction for Chemical Plant

Their high resistance to corrosion has made plastics of great utility to chemical engineers and applications of these materials in chemical plant are many and varied—ranging from huge fabrications in rigid PVC to small valve and pump packings in PTFE, and including not only actual chemical plant, pipework, fittings, etc. in plastics, but also protective coatings, chemical-resistant cements for constructional work, resins, etc. New plastics materials, new ways of moulding and extruding, new techniques of welding and fabrication, new ideas in reinforcement and in joining to other materials, new properties given by high-pressure processes, irradiation, etc., all make plastics an exciting field of exploration for the chemical engineer in search of corrosion-resistant materials. We present on these pages one or two recent developments that will be of interest to C.P.E. readers, while following is an authoritative, practical article on the use of thermoplastics in chemical plant construction.

Reinforcements for 'Bakelite' Resins

By employing reinforcements other than glass fibres or fabric, users of *Bakelite* polyester and epoxide resins are now extending the range of these materials to meet unusual or more stringent requirements, particularly in the corrosion field. Among the reinforcements now being employed are metal rod, *Dynel* acrylic fabric and *Terylene* polyester fabric.

Metal rod, for example, is used for reinforcing the frames of washable air filters made from *Bakelite* polyester resin, and woven polythene fabric. Here, a flexible grade of polyester is used to ensure that the filter makes an airtight seal in its housing.

In conjunction with epoxide resin, *Dynel* acrylic fabric enables a laminate to be produced which will withstand acid and alkaline conditions. A typical use is in the fabrication of small tanks in which coiled coil filaments for electric light bulbs are processed. The coils are shaped on iron wire formers which are then dissolved out with acid; after this, the coils are washed with strong alkali. This means that the processing tank has to withstand both acid and alkaline conditions alternately.

Terylene reinforcement for polyester and epoxide resins is employed for troughs, ducting and containers used in the pharmaceutical and food processing industries where glass contamination would constitute a major hazard. In large applications, or in other cases where the cost factor rules out the use of *Terylene* for the whole unit, it is accepted practice to build up a composite laminate using glass reinforcement for the bulk of the laminate and *Terylene* in the surfaces which come into contact with the materials being handled.

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PTFE Thin-walled Tubing

The production of *Fluon* (PTFE) in a very fine state of division in aqueous suspension has made it possible, by coagulating the suspension, to extrude the material in thin-walled tubing. This has the immense advantage over thick-walled tubing (which was all that could be made from the granular form of the polymer) of considerable flexibility and resistance to flexural fatigue.

According to an announcement from Crane Packing Ltd. (one of the Tube Investments companies), these thin-walled tubes are already widely used in the aircraft industry where their long life is no insignificant factor in reducing maintenance costs; and they are likely to prove valuable as flexible hose liners in many other applications in industry and in research laboratories.

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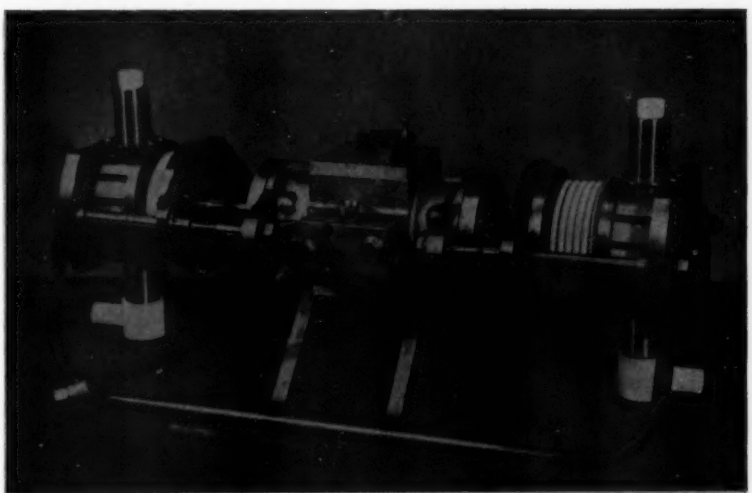
Bellows Pump for Corrosive Duties

Another development of Crane Packing Ltd. is a bellows pump which



Double-ended Crane bellows pump, all 'Fluon'-lined for handling highly corrosive liquids and gases.

has all parts which come into contact with the fluid made of *Fluon* PTFE. The pump can, therefore, handle successfully all known chemicals and solvents except fluorine and the molten alkali metals, within specified temperature and pressure ranges. In addition, although the pump is basically designed for handling clear fluids, it can also function successfully with liquids which have solids in suspension so long as they are not by nature likely to silt up the convolutions of the bellows or prevent the valves operating.

The pump consists of a simple bellows made of *Fluon*. This is blanked off at one end, and at the other end forms a valve chest incorporating two conical seat gravity valves. The motive power is supplied by a reciprocating air motor with a fully-adjustable stroke and sensitive throttle control. The pump unit is directly coupled to an extension of the piston rod. The pump can be supplied in either single- or double-ended form. The single pump unit gives intermittent delivery, whereas the double unit will give almost continuous delivery.

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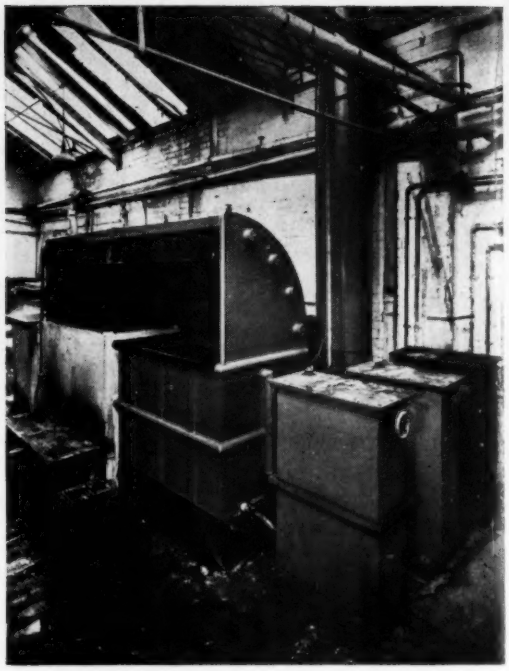

Dipping cabinet in 'Cobex' rigid PVC, referred to on this page, and installed by Plastic Constructions Ltd. at the works of Metal Finishing, Birmingham.

Rigid PVC in Metal Finishing Industry

Among the many uses of *Cobex* Rigid PVC sheet in the chemical and allied industries has been the application of this material for the manufacture of special process units, for the chemical treatment of metals.

A recent development in this field, revealed by BX Plastics Ltd., has been the introduction of a dipping cabinet for use with the Albright & Wilson *Phosbrite* 159 chemical polishing process for aluminium components.

With the exception of the actual process tank, which is fabricated from stainless steel in view of the elevated temperature to which it is subjected, the unit has been fabricated from *Cobex* sheet and tube, including the centrifugal exhaust fan, and discharge ducting.

An interesting feature in the design of this plant is that the fumes are exhausted through slots in the canopy, and passed through a wash cyclone, the inside of which is helix shaped. A number of waterspray jets are incorporated in this cyclone, together with a neutralising reagent. The centrifugal movement of the fumes in the cyclone assists extensively in segregating the moisture out of the fumes, which can then be easily drained, the fumes being exhausted to atmosphere.

In view of the highly corrosive nature of the process involved, it is absolutely essential that a material is used throughout, which is completely inert, and it has been found through experience that *Cobex* has adequately met this requirement.

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Glass-fibre-reinforced Plastics Fabrications for Handling Chemicals

Glass-fibre laminates made from polyester resin have found favour for vehicles, boats, aircraft etc., but despite their corrosion-resistance and high strength/weight ratio they have not made the progress which was at first anticipated in the chemical and plating industries. An explanation that has been put forward is that, owing to capillary action between the resin and the glass reinforcement, there is a large surface area of the fibres exposed to chemical attack and the result is a gradual decrease in the strength of the laminate.

To overcome this, a system that uses two distinct layers of reinforced resins has been introduced by A. E. Griffiths (Smethwick) Ltd. The first layer—the one in contact with the corrosive fluids—is made from furane, which has exceptional chemical resistance to acids and alkalis but little mechanical strength. Layers of reinforced polyester are built up on top, therefore, to produce a 'twin-shell' structure. For even more exacting conditions, other resin combinations, such as epoxy/furane, are possible.

As well as tanks, the 'twin-shell' system is used for the manufacture of ducts, pickling trays etc.

This 3-in. PVC pipe union, introduced by theWalworth Co., U.S., extends the uses of PVC piping in the chemical, food, oil refining industries, etc.

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Bigger PVC Pipe Unions

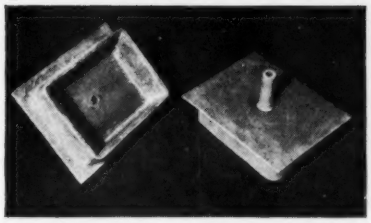
What is claimed to be the first plastic 3-in. screwed pipe union has been introduced by the Walworth Co., New York. Made of rigid polyvinyl chloride, it increases PVC piping application possibilities which have been limited by the availability of only smaller-sized unions.

Specially designed surfaces in the joints of the three-part union provide a tight seal against flow leakage. Weighing about a pound and a half, the 3-in. union is easily handled and installed. A knurled ring provides a better grip to further simplify installation.

Plastic Pipe and Fittings

Plastic pipe and fittings, designed to cover a wide field of chemical applications, are now available and a complete installation in the same material can be provided.

This means that from the beginning of the run of pipe to the end, the fluid or gas passing through the installation will not be in contact with any other material. All sockets, bends, T-pieces, plugs, caps etc. will be made of the same compound as the pipe itself.



These small tanks are produced by Mendip (Chemical Engineering) Ltd. in 'Bakelite' polyester and epoxide resins reinforced with 'Dynel' acrylic fabric.

As an extension to this, it is made certain that the jointing methods do not introduce any other elements into the installation which might have different corrosion-resistant characteristics from those contained in the pipe. Thus, for concentrated inorganic acid lines, *Durapipe* Z pipe is available with fittings welded by a special technique to the pipe without the introduction of any other material, such as adhesives, heating coils etc.; for other suitable applications such as crude oils, *Durapipe* K can be obtained with cement welded fittings where the joint is formed in such a fashion that the fitting and pipe become homogeneous. With *Durapipe* N for high aromatic and other solvent applications a special cement for the fittings produces a true chemical bond by a condensation reaction between the constituents of the cement and the surface of the pipe and fitting to be joined.

These jointing methods, which are an alternative to screw joints, which are also available, are becoming increasingly popular in the chemical process industry, according to Richard E. Du Pont Ltd., the suppliers.

THERMOPLASTICS IN CHEMICAL PLANT

By S. G. Evans
(*Rediweld Ltd.*)

Valuable information is given here about PVC and polythene as materials of construction for chemical plant, and some practical comments on welding procedures are included. The author then goes on to discuss the various applications of these thermoplastics in industries where corrosive liquids and fumes are handled and concludes with some brief comments about other plastics.

PLASTICS as materials for the construction of chemical plant are today firmly established. During recent years the variety in which these materials can be obtained has greatly increased and new techniques for their transformation have been developed.

This article is confined to the discussion of thermoplastic materials and in particular to polyvinyl chloride and polythene. Both of these lend themselves to heat working and forming into tubes, sheet, rod, block and mouldings of all kinds, most of which may be further shaped or moulded as required during construction. Another and very important property of PVC and polythene is their weldability; using a filler rod of the same or similar material, it is possible to obtain very sound welds and to build up in this way quite complex structures. In selecting which of these materials is best suited to a particular job, it may be useful to consider some of their physical properties.

Properties of PVC and polythene

Natural polythene is a translucent, white, wax-like material, easily indented with a finger-nail and quite pliable in thicknesses up to $\frac{1}{4}$ in. Polyvinyl chloride polymer is a coarse white powder which may be compounded with suitable fillers, stabilisers etc. to give a wide range of colours and grades of material. In the unplasticised form, these materials can be obtained transparent or opaque, and sheets of $\frac{1}{8}$ in. thickness are quite rigid.

Polythene has a specific gravity of 0.92 to 0.96 as against that of PVC which is 1.38 to 1.45; its tensile strength is much lower (3,000 p.s.i. against 7,000 p.s.i.) but its elasticity and very high resistance to shock give it an advantage over PVC, which is generally rather brittle.

Polythene withstands most acids and alkalis and, in particular, is resistant to hydrofluoric acid for which it provides the most satisfactory material for containers and dispensers. It is only very slowly attacked by strong oxidising agents, is insoluble in organic solvents at ambient temperatures but tends to swell with some, and at higher temperatures may be slowly dissolved. It is not suitable for use with aromatic or chlorinated aliphatic hydrocarbons. There is little to choose between the chemical resistance of polythene and PVC, though the latter is not affected by hydrocarbons and may be used with oils.

Polythene is generally used in its white or natural form for indoor applications, but for outdoor installations

a carbon black pigmented form is used to eliminate embrittlement due to exposure to ultra-violet rays. PVC has the advantage of greater structural rigidity and dimensional stability at relatively low temperatures. At temperatures exceeding 60°C. both lose mechanical strength rapidly with temperature increase and their value as a material of construction for chemical plant is lost owing to deformation at these temperatures.

'Linear' polythenes

The newer types of polythene which have recently become available have considerably greater resistance to heat and can therefore be used for containers which have to be sterilised by immersion in boiling water or even low-pressure steam. It would be beyond the scope of this article to discuss the merits and disadvantages of the various types of polythene. Suffice it to say that these newer types, sometimes referred to as 'linear,' are more crystalline than the better known and older forms, which are partly amorphous and partly crystalline. Linear polythenes are harder and have greater tensile strength; they are, however, more difficult to transform and some of them cannot yet be processed satisfactorily with the machinery at present available. Not enough is yet known about these new materials to recommend their use in chemical plant. The great expectations which arose when they were first introduced may not materialise and a certain amount of caution is recommended in their use.

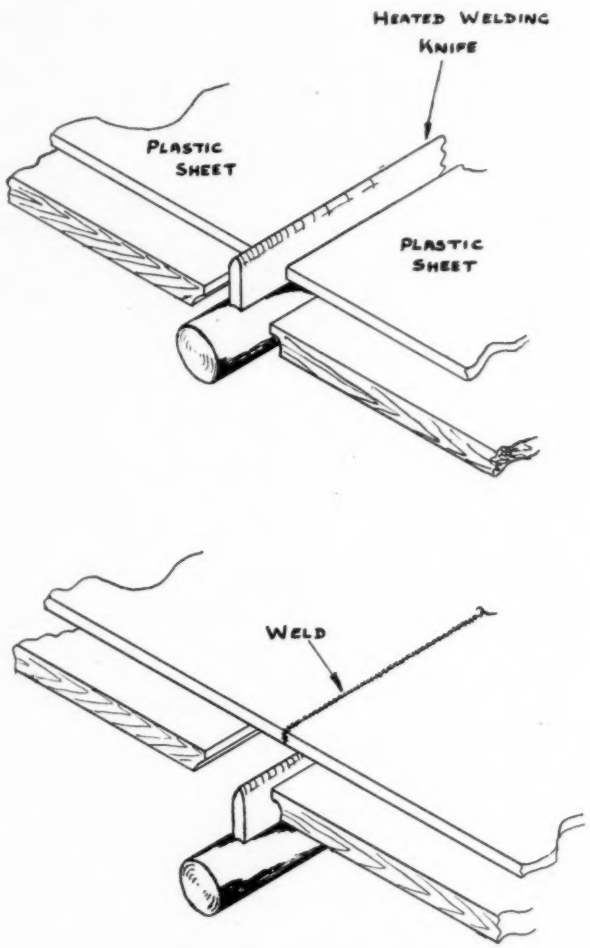
Welding procedure for thermoplastics

The importance of the weldability of both PVC and polythene has already been stressed. Welds are made by a method somewhat similar to that employed for the gas welding of metals, using a filler rod of the same or similar material and applying heat and slight pressure to unite the rod with the parent material. In the case of metal an oxy-acetylene, butane or propane flame is employed as the source of heat. It is not possible to use these for the welding of PVC or polythene as the high temperature of the flame would cause decomposition of the material.

For the welding of thermoplastics a stream of compressed air or nitrogen, heated to approximately 300°C., is used to soften or melt both the filler rod and the material being welded The use of nitrogen is recommended for welding of polythene to prevent oxidation. Quite passable welds in polythene can also be made using compressed air, and these may be used in the case of structures of minor importance. Such welds are, however, definitely inferior in mechanical properties.

Two basic types of welding torch are in use. In one, the stream of compressed air or nitrogen is heated by passing it through a coil which surrounds a burning gas jet, whilst in the other, heating is provided by an electric element. The edges of the material to be welded together are first chamfered using a triangular scraper, sharp knife, file or router. The weld is laid by directing the jet of hot air or inert gas at the point where the filler rod is being fed into the junction of the component parts. By a slight weaving movement of the torch the jet is directed in an arc travelling a short distance down the filler rod and along the seam to be filled. Where the rod is of a lighter cross section than the parts being welded, the heated gas jet is allowed to play on the heavier section for a longer interval. As the rod melts or softens it is pushed steadily forward into the preheated groove.

It is important that the follow-up pressure is maintained on the rod as it is laid down into the seam. Any relaxation, permitting the softened rod to lift again, may result in air being



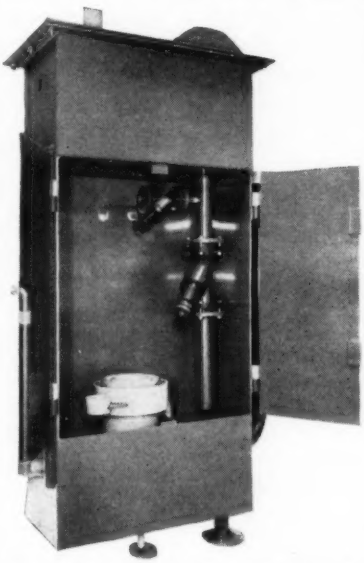
Sketch showing method of sword welding.

trapped and a weakening of the weld. If the filler rod is unduly stretched by pushing it forward too quickly, stresses will result in the weld with the attendant risk of failure.

Automatic welding developments

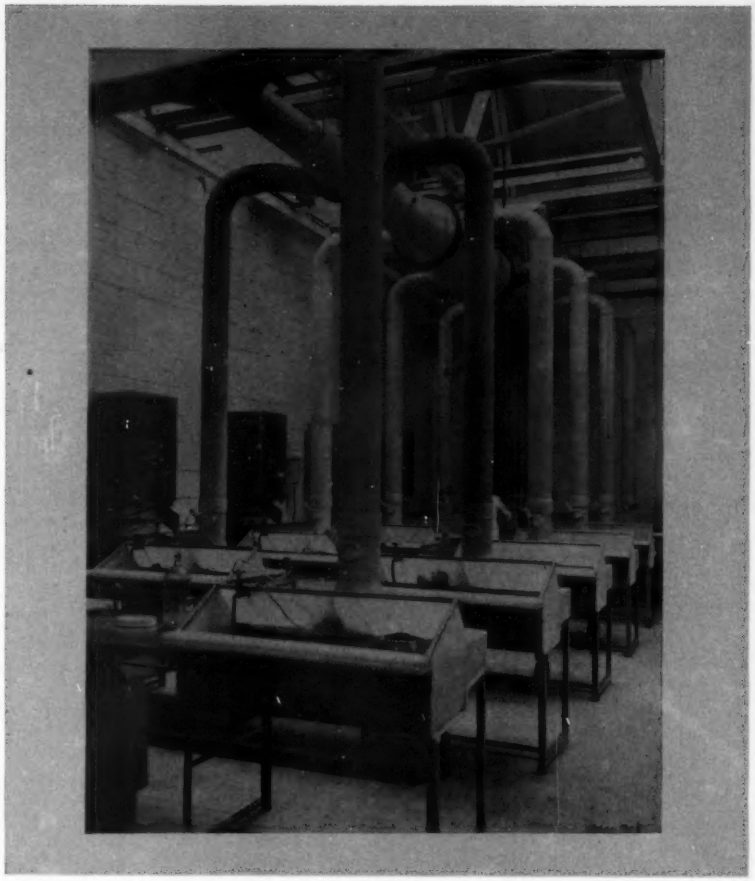
New equipment now available for use for welding plastics includes semi-automatic and fully automatic torches. In the case of the former, the torch is held in the hand as before, but the welding rod is held by the torch and fed automatically into the groove previously prepared. In the latter, the torch runs on rails and, after presetting, carries out the actual welding operation entirely on its own. Both these machines serve to increase welding rate and efficiency by removing the variable human element. In general, a weld, ground and finished flush, has a strength of approximately 60% of that of the parent material. However, a weld left proud may have a considerably higher strength owing to the increase in cross section at this point.

Butt or heated-tool welding and friction welding can also be employed. Heated-tool welding is of particular value in the case of the new polythenes,



Automatic water control for ammonia washers made entirely from PVC.

as the ordinary gas welding process is no longer applicable. A variety of tools have been developed for heated-tool welding and, in addition to the ordinary thermostatically controlled hotplate, a so-called sword welder is now being used. The sword welder employs a vertical, heated knife blade which, moving in a vertical plane, may be raised above or lowered below a table top (see the accompanying diagram). This equipment is particularly useful for making straight joints up to 4 ft. in length. Irregular shapes can also be welded using curved or shaped blades. The temperature generally employed for heated-tool welding is approximately 200°C.



Plating shop baths and exhaust system in polythene.

Machining

Both polyvinyl chloride and polythene lend themselves freely to machining with most of the conventional wood- and metal-working tools. Circular and band saws can be used, and an ordinary hand saw will cut polythene easily. A fine-toothed saw or hacksaw is preferable for PVC as coarse-cut saws tend to splinter the material. Triangular scrapers and cheese files are very useful for preparing edges to be welded and for facing off finished welds. Another tool which is used extensively for shaping and finishing is the small, motor-driven, abrasive belt.

Drilling, turning and milling of PVC is in general easier and quicker than machining mild steel. Speeds for these three operations may be respectively twice, four and six times faster.

For the machining of polythene a fine feed and speed of approximately 750 ft./min. is used, but care must be taken to clear swarf constantly to avoid smearing due to frictional heat. A lubricant is used in the case of PVC but none is required for polythene. Care must be taken to keep a good edge on all tools as it is found that these are more quickly blunted than when machining mild steel. The use of threads is not generally recommended with PVC and polythene as both are notch sensitive. However, if a thread is used, knuckle or acme forms are most suitable.

Chemical plant fabrication

The ease of construction with PVC and polythene and their excellent chemical resistance have led to their widespread use in the manufacture of

chemical plant. In many cases the whole construction depends on these materials but they also have a large application, replacing less efficient but more conventional materials for certain component parts only. In the chemical industry, in its strictest sense, where corrosive liquids, solids or vapours are used, supply lines, effluent lines, containers and fume exhaust ducts may be made of either PVC or polythene.

The construction of plastic fume exhaust systems is largely comparable in method to that normally employed in sheet metal work. Flanged or slip joints are both used, the latter being very useful in allowing expansion and contraction of the system to take place freely. Mild-steel backing flanges are used and, for large ducts in polythene, steel tubes and rods sleeved with polythene tube give added structural rigidity.

A wide range of fans are made in PVC for use in either coaxial or venturi systems. In the smaller size fans the rotor is often a polythene moulding which, apart from being cheaper to produce, can be made to closer tolerances. Radial flow exhaust fans are produced nowadays with outputs of about 12,500 and 16,000 cu.ft./min. at static pressures of $1\frac{1}{2}$ in. and 6 in. respectively. Some fans have been built completely from polythene, and the number may increase provided that the present experiments with linear polythenes for their construction prove successful.

Valves and pumps in plastics

Supply and effluent lines using extruded tube may also incorporate valves and pumps constructed entirely from plastics materials. Polythene valves are often constructed almost entirely from moulded components, whereas those made from PVC are fabricated from tube, rod, sheet and block.

In PVC pumps adequate clearance must be allowed between the rotor and housing in order to prevent generation of frictional heat, smearing and subsequent distortion and breakdown of these parts. These pumps are not suitable for use with sludges. The main problem, which so far has prevented the large scale use of PVC or polythene pumps, is the difficulty of obtaining a satisfactory seal or gland. PTFE and artificial rubber rings and packings are not entirely satisfactory and often cause failure. As in all pumps, the gland or packing is the most important part and, if this does not stand up to the wear and tear usually experienced, the pump becomes a liability even though the housing and rotor remain undamaged. Various small, hand-operated pumps are available for the conveyance of acids and alkalis from one container to another.

Containers for corrosives

In addition to a wide range of polythene laboratory apparatus, a variety of buckets, safety jugs, winchester carriers and other containers are in use for the safe handling of corrosive substances. Larger static containers may be built solely from PVC or polythene, or they may be wood, concrete, brick or metal structures with a plastic lining. These last-mentioned will have the advantages due to the structural strength of the basic container, together with the resistance of the lining material. In the case of PVC it is possible to cement the plastic sheet to the tank being lined, but there is no satisfactory adhesive for polythene. This material is, therefore, of less value when very large tanks have to be lined.

Plasticised polyvinyl chloride sheet is widely used as a tank lining material. It can be cemented into position and is not affected by any expansion and contraction of the parent container. Another advantage is its very high impact and abrasion resistance. The incorporation of plasticisers may, however, reduce chemical resistance, and this factor does provide some limitation of the uses of the plasticised material.

Plating shop side extraction and general exhaust system made in PVC.

Widening range of chemical plant in plastics

The following list gives some indication of the variety of items of chemical plant which have been constructed from plastics: absorption towers, condensers, distributors, filter presses, fume cupboards, fume ducts, gas filtration units, heat exchangers, measuring and mixing devices, pumps, reaction chambers, scrubber units, tanks and tank linings, valves and fans.

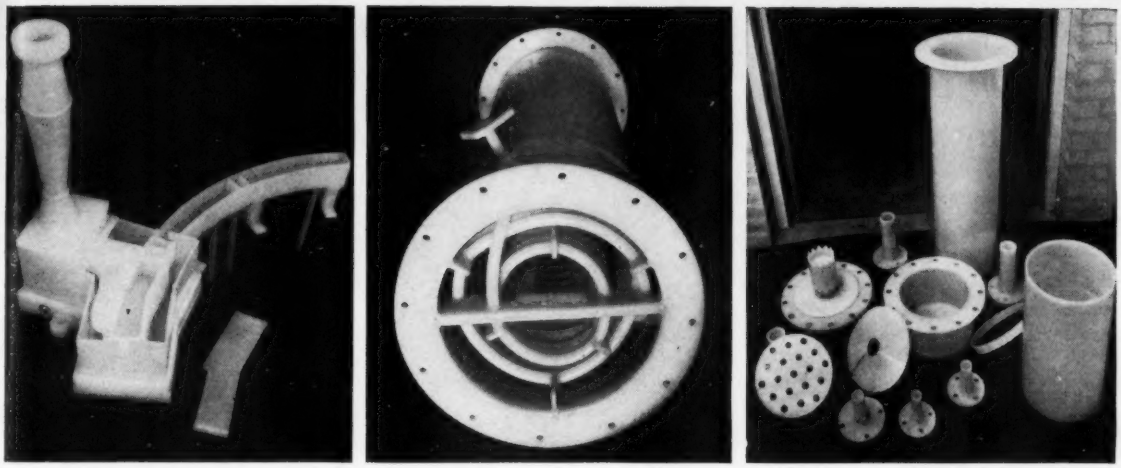
Plastics also find a wide application in many industries other than those strictly referred to as 'chemical.' In the electroplating industry, anode carriers, pickling baskets, stirrers, tank linings, fume hoods and exhaust ducts are fabricated from PVC and polythene on an ever-increasing scale. In the photographic and printing industry these materials may be used for developing tanks, racks and sink linings. In the case of colour films most complicated automatic developing and printing machines, constructed almost entirely of PVC, are in use. In the electrical and radio industry (apart from their extensive use as insulating materials), PVC and polythene are used in the construction of spray washing machines and hydrofluoric acid etching fountains, which are used for television tubes. In the food industry they are used as linings for containers and pipe for conveying fruit juices etc.

Linings for isotope containers

Another and growing field in which these materials are employed is connected with radioactive isotopes. Isotope containers lined with lead foil and with an inner lining of PVC have been used; such containers are easily scrubbed out with acids or alkalis without damage. Effluent lines in polythene are employed to carry off radioactive wastes.

Filter cloths

Filter cloth made from PVC, polythene, nylon or *Terylene*, is extensively used by the chemical industry. Such cloth is woven from staple fibre, continuous filament or a mixture of both. Available in a number of different weaves and weights, they cater for most of the applications where previously cotton or wool were used. Synthetic filter cloths are usually much stronger and give long service, more than justifying their higher initial cost. When cut with a heated knife, the



These three pictures show (*left*) hydrofluoric acid crystal etching apparatus, (*middle*) reflux condenser and (*right*) component parts of a chemical reaction vessel, all made in polythene by Rediweld Ltd.

edges of the cloth are fused and protected from fraying. Filter bags can be sewn on most ordinary sewing machines, using a vinyl or *Terylene* thread.

Other plastics for chemical plant construction

Among other plastics used in chemical plant, polymethylmethacrylate (*Perspex*), PTFE and polyisobutylene may be mentioned briefly.

Polymethylmethacrylate is a glass clear, hard material which can be very highly polished. It is used for making inspection windows in fume cupboards and reaction vessels, and in the cinematograph industry for making reels and rollers used in developing tanks, where its high surface finish prevents scratching of the film. Its resistance to acids and alkalis is not particularly good but it can be used with weak acids. It has little resistance to most organic solvents.

Polytetrafluoroethylene, with its comparatively high working temperature of 250°C. and extremely low coefficient of friction, is extensively used for making bearings, bushes, sealing rings, valve packings, joints and gaskets. Its anti-adhesive properties also make it ideal for rollers handling sticky materials.

Polyisobutylene, mixed with carbon and graphite, or with 10% polystyrene is available in sheet form. With suitable adhesives this sheet may be bonded to steel, lead, wood, aluminium or concrete and is employed widely as a tank lining material. Its resistance to acids and alkalis is good, but it is not suitable for use with benzene, acetone, fatty acids or ether.

In a great many cases the extreme usefulness of thermoplastics, as materials for the construction of plant in the chemical and allied industries, has been proved during the last few years. It is hoped that the measure of confidence in these materials thus gained will lead to their even larger application in the future.

Air Pollution Control

Pollution of the atmosphere by processes releasing solvents, carbonaceous smokes and other combustible materials—possibly in small yet objectionable amounts—can, it is claimed, be brought under control in many cases by the use of 'oxycat' units. These, which are described in *Engineering*, November 1956, p. 586, are simple, brick-shaped units, consisting of two ceramic end plates connected by a large number of parallel spaced rods the surfaces of which have been impregnated with a catalyst material. This material, catalytic alumina and an alloy of platinum, promotes the combustion of the pollutant with the oxygen of the carrying air as this passes through the unit at a suitably high temperature.

The units are about the same size as a normal brick and can therefore readily be stacked up to form a bed across a duct or flue. Normally it is necessary to have a heating unit on the inlet to the bed in order to start the oxidation reaction on the catalyst surface. A temperature of at least 500°F. is usually required. In many cases, once started, the reaction is thermally self-sustaining through the heat released, but this depends upon the amount of pollutant present in the air being treated. In some cases sufficient heat is generated to be worth while recovering.

Typical applications in which the system has proved successful are in carbon black and rubber processing, paint stoving and wire enamelling, potato frying and meat cooking, impregnating of wood with resin, and in printing works where the exhaust contains solvents used in making printing inks.—*U.K. Technical Digest No.* 817.

Sodium metaphosphate. A technical leaflet published by Albright & Wilson (Mfg.) Ltd., 1 Knightsbridge Green, London, S.W.1, describes a method for determining sodium metaphosphate in the very low concentrations—often as little as 2 p.p.m.—in which it is used in the threshold treatment of water. The leaflet, an amplification of a description previously published by the company, points out that no suitable direct method of determining metaphosphate in very low concentrations has yet been found. Metaphosphate may, however, be converted into orthophosphate by boiling in an acid solution. The method described determines the metaphosphate as the difference between the orthophosphate found in water on first sampling and that found after conversion of the metaphosphate.

Solvent Separation of Oleines and Stearines

Completion of a second unit for the production of stearines and oleines, using the American solvent separation process for which they acquired the British rights just after the war, has been announced by Price's (Bromborough) Ltd. The process is carried out in a complex chemical plant, most of it in stainless steel because of the corrosive effects of fatty acids. This article includes a description of the process.

AN important development in the manufacture of oleines and stearines is announced by Price's (Bromborough) Ltd. This company is the first in Britain to produce these materials solely by the modern process of solvent separation. As a result they are able to achieve a significant improvement in the standard of quality.

Following their introduction of this method of manufacture into this country in 1950, the company has now built and brought into operation a second *Emersol* plant of the type developed in America by Emery Industries Inc. of Cincinnati. With two plants in full production the company is able to obtain increased production of high-grade products and to abandon the old method of hydraulic pressing. From now on their whole output of oleines and stearines will be produced by the *Emersol* process.

Fully automatic, this method of manufacture achieves a high degree of separation which, in most cases, is carried out in one operation. Automatic regulation at every stage of the process enables strict quality control to be maintained throughout. Since the whole operation is fully enclosed there is a complete absence of impurities from the outside.

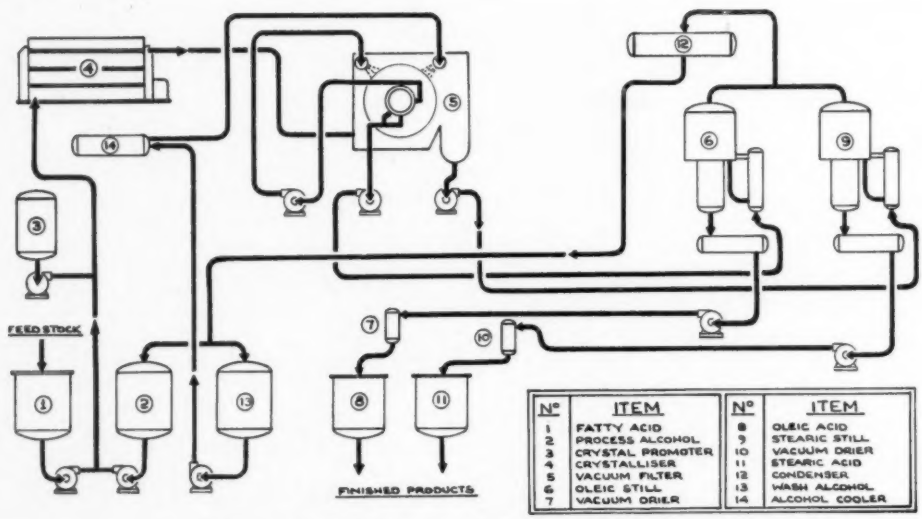
Up until now, the original *Emersol* plant has been fully employed producing the oleines and stearines required by industry. Now that two plants are in full production the company will have an opportunity of testing and developing the full potentialities of the process.

The process also permits the use of a wider selection of raw materials. Price's believe that it will enable them to improve their processing of individual fats and oils, thus producing materials with particular characteristics to meet specialised demands. For example, it is considered that if soya bean-oil fatty acids are processed by solvent separation it should be possible to achieve an almost complete segregation of the drying acids which, on re-esterification, would give a better drying oil. Used in the manufacture of alkyd resins, an improved product can then be obtained.

Fat splitting

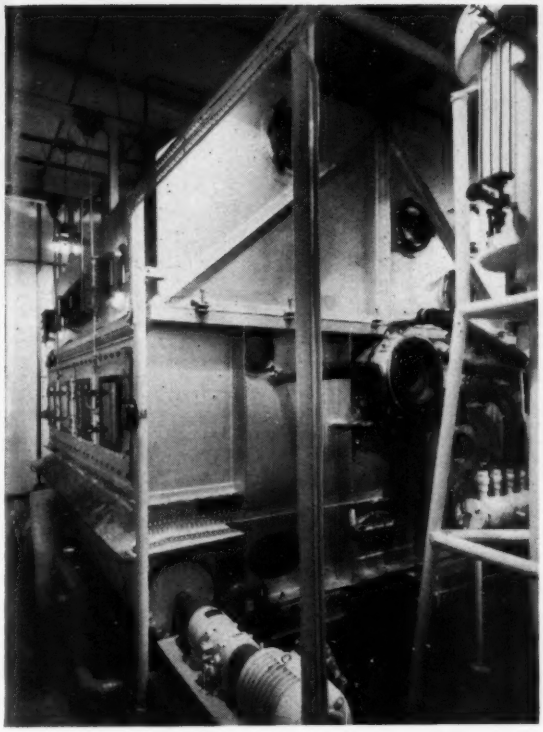
In order to obtain stearine and oleine, the natural raw fats which are compounds of fatty acids and glycerine are subjected to a 'fat splitting' operation which separates the fatty acids from the glycerine. The fatty acids, which are comprised of mixed soft and hard compounds, are then distilled, and the resulting high-grade product processed to separate the stearine (or solid portion) from the oleine (or liquid portion).

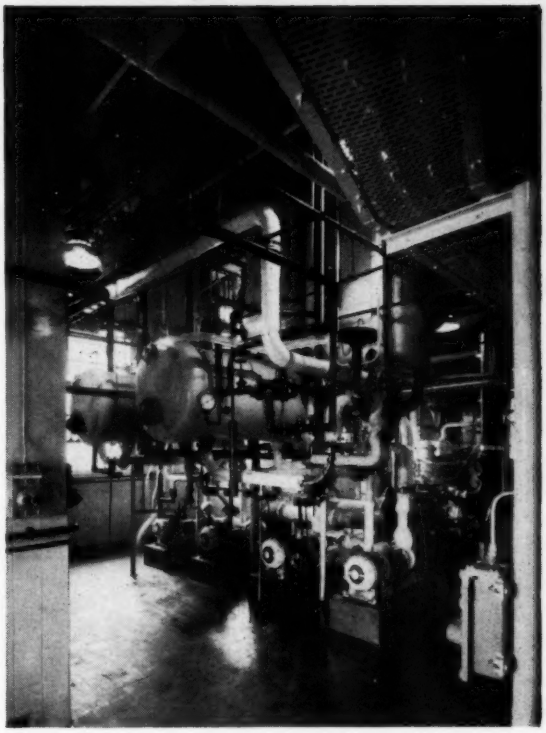
The crude fatty acids from the splitting process are now distilled in stainless-steel vacuum stills provided by George Scott & Sons Ltd. and



Nº	ITEM	Nº	ITEM
1	FATTY ACID	8	OLEIC ACID
2	PROCESS ALCOHOL	9	STEARIC STILL
3	CRYSTAL PROMOTER	10	VACUUM DRIER
4	CRYSTALLISER	11	STEARIC ACID
5	VACUUM FILTER	12	CONDENSER
6	OLEIC STILL	13	WASH ALCOHOL
7	VACUUM DRIER	14	ALCOHOL COOLER

Simplified flow sheet showing the various stages of the Emersol process.





Left: **The vacuum filter where the actual separation is effected. The chilled slurry is filtered on a rotating drum, the methanol solution of oleic acid being withdrawn along the axis, and the stearic cake falling into the melter.** *Right:* **The ground floor of the building showing the lower section of the stills and the reboilers where the last trace of methanol is removed.**

W. J. Fraser & Co. Ltd. Sweet water containing the glycerine is, after treatment, concentrated in a new Kestner climbing-film evaporator.

Solvent separation

The solvent separation process for the manufacture of oleines and stearines depends on the fact that, at a suitably low temperature, oleines remain soluble while stearines become insoluble in methanol. The distilled fatty acids are dissolved in 90% methanol (25 to 30% soln.) and a small quantity of a crystal promoter is added to assist the filtering and washing of the crystallised stearine.

The solution is pumped to the crystalliser where it passes in series through a bank of jacketed tubes enclosed in thick thermal insulation. Here it is chilled. Each tube contains a chain-driven, rotating scraper to assist the formation of uniform-size crystal and promote heat transfer.

From the crystalliser the slurry containing the precipitated solid acids flows to the vacuum filter where separation of the oleines and stearines is effected. The filter, completely enclosed in a hood, is contained in a cold room which is maintained at a low temperature by a room cooler operated by the evaporation of ammonia. It is therefore possible for the operator to make any necessary adjustments to the filter without affecting the process.

The slurry passes on to a filter cloth which is in contact with a rotating drum. Solvent washes sucked through the cake draw off the liquid oleines along the axis of the drum. The filter cloth helps to consolidate the cake, maintaining the vacuum. The pores are kept clean by spraying with warm methanol.

The solid stearic cake is removed from the surface by a string discharge and falls into the melter—a steam-jacketed trough—from which it is pumped to the stearic still.

In this vertical distillation unit the residual solvent is removed and recovered for future use. The stearine passes through a cooler to storage.

APPLICATIONS OF OLEINES AND STEARINES

Industrial demand for oleines and stearines comes from a wide range of manufacturers but mainly from the textile, chemical, rubber, plastics, soap and lubricants industries. To mention only a few uses:

Oleine forms the basis of the cloth and wool oils required for carding and spinning of virgin wool and for the processing of waste woollen cloth to form shoddy.

Oleine is also used in finishing processes for man-made fibres, while in the cotton trade it is frequently used in kier boiling.

In the chemical industry, oleines and stearines are well known as raw materials for a wide range of organic and fine chemicals; their salts and esters find application in a large number of industries.

Oleine soap is used in the production of foamed rubber while stearine serves as a lubricant in reclaiming waste rubber and is an essential ingredient in compounding and vulcanising. Stearine is also used in compounding synthetic rubber.

In the plastics industry, and to a less extent, oleine acts as an internal lubricant and mould release agent in the manufacture of thermosetting moulding powders for compression moulding.

Stearine is the lubricant and leafing agent which enables metal to be finely pulverised to produce metal pigments for use in paints.

The filtrate containing the oleine is pumped through heat economisers (which enables almost 75% of the refrigerant to be recovered) and is then preheated before passing to the oleic still. Here the solvent is removed under controlled conditions to prevent esterification, overheating or discolouration. The oleine passes through vacuum drier to the storage tank.

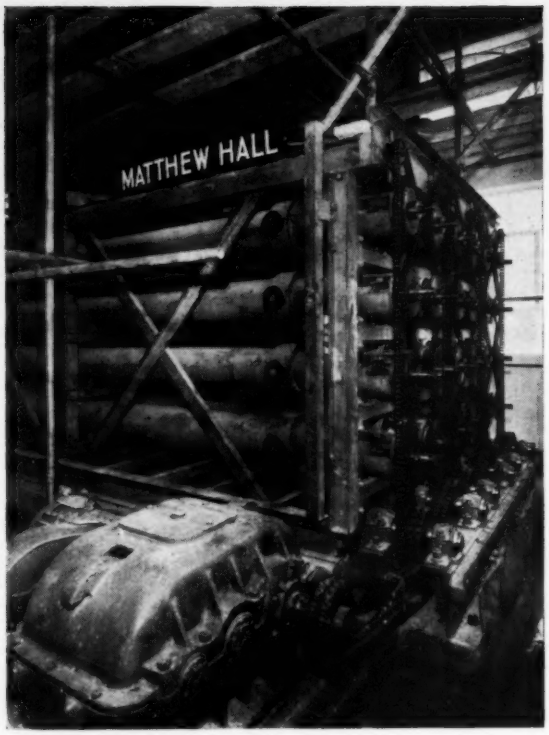
Automatic control

The whole process is continuous and virtually automatic. The plant can be operated by one man, but for reasons of safety the usual practice is to employ two.

The plant includes its own refrigeration system in which methanol is circulated through a heat exchanger in countercurrent flow to cold filtrate from the filter. After passing through a standard ammonia refrigerator the methanol continues to the jackets of the crystalliser tubes. Waste steam from the refrigerator is used for process heating and evaporation of the solvent. This lack of waste and the almost complete recovery of the solvent are features of the process which make it very economical to operate.

Plant and equipment

The plant was designed by the Blaw-Knox Co., Pittsburgh, U.S., and was erected by Matthew Hall & Co. Ltd. Civil engineering work was carried out by John Laing & Son Ltd.



The crystalliser as it was after being placed in position ready for insulation. The horizontal stainless-steel tubes are enclosed in jackets through which the chilling liquid passes. Each tube is equipped with a chain-driven rotating scraper to assist the formation of uniform-size crystals and promote heat transfer.

Rubber in heavy engineering. The scope of rubber in many branches of the engineering industry has been greatly enlarged since the possibilities of rubber as a true engineering material were first recognised. Today it is still finding new uses and a paper presented by Mr. S. W. Marsh at the Natural Rubber Development Board's conference on 'Rubber in Engineering' recently provided a useful general outline of the uses of rubber in heavy engineering, including buildings. This paper has now been published as a 54-page, fully-illustrated booklet by the Andre Rubber Co. Ltd., Kingston By-pass, Surbiton, Surrey.

The paper is divided into four sections, dealing respectively with ships and jetties, general engineering (including buildings), couplings, and railway engineering. The author's approach is essentially practical and numerous photographs or diagrams accompany the discussion of specific experiments and actual problems solved.

The Leonard Hill Technical Group—July

Articles appearing in some of our associate journals this month include:

Paint Manufacture—American Packaging Practice; The Use of Drying Oils in the Paint and Allied Industries; Packaging Research; The Location of the Paint Industry, 3; The Blooming of Nitrocellulose Varnishes; Package Design; Paint and Lacquer Additives, 3.

Dairy Engineering—Frozen Milk by Ultrasonics; Revised Ideas on Bottle-Washing Detergents; Instruments in the Dairy; The Dairy Industry in Czechoslovakia; British Butter Factory Beats World Production Record; Report of N.D.A. Conference at Torquay.

Petroleum—Planning an Electric Computer System; The Oil and Natural Gas Industry in Pakistan; Hydrogen Treating in the Refinery; Exporting Equipment for the Oil Industry.

World Crops—Conservation of Grain in Britain; Improving the F.A.Q. Wheat Sample; Wheat Quality; Control of Rats and Mice in Grain Storage; Hazards of Grain Dust.

Atomics—Engineering Problems of Nuclear Power, 3; Coolant Gas Circuits; Reactor Calculations; Dounreay's Fast Reactor; Dounreay's Materials Testing Reactor; The Chemical Group at Dounreay; A New Type of Atom Smasher; Atomic Progress in Czechoslovakia; The Future of Nuclear Power; Canada's Uranium Prospect.

Automation Progress—Control of Index Conveyors; Flow Production and Die Castings; Design and Use of Hydraulic Servo Systems; Control of Skip Winding in Collieries; High-Speed Electronic Reproduction; Automatic Data Reduction; Electronic Controls for Industry.

Corrosion Technology — Corrosion Problems in a Blast Furnace Water Cooling System; The Rôle of Corrosion Inhibitors in Water Treatment; Prevention of Corrosion by Water Treatment; Corrosion in Boiler Fireboxes; Corrosion Research Laboratories—12, Ministry of Supply Outdoor Paint Exposure Station at Glascoed, 2.

Recent Developments in

MIXING

By D. F. Riley, B.Sc., A.C.G.I.

Liquid mixing; liquid-liquid extraction; agitation in the aeration of biological waste treatment; mass transfer in suspensions; mixing of particles of solids, etc.

ONE of the principal aims of research in the field of liquid mixing is to enable equipment to be designed to achieve predictable rates of mass transfer or heat transfer, with the minimum power consumption. Such a technique of design would involve an accurate knowledge of the effect of impeller type, diameter and speed on both the power consumption and the rate of transfer.

It is also necessary to know how the process variables such as surface tension, viscosity, density, diffusion coefficient and thermal properties affect the transfer rate. We are at present only just beginning to acquire this knowledge and the amount of information which is of practical use in design work is severely limited. It is, however, growing and during the last year or so several papers have been published on the subject.

In two papers the factors involved in determining the blending time of miscible liquids are considered while others are concerned with the continuous dispersion of liquids in liquids. One of the more important applications of gas absorption in agitated liquids is to be found in the oxidation of biological and other wastes and several papers treat this aspect of mixing. Our knowledge of the relative performance of different standard designs of powder mixer is increased by one paper on this subject, while another reviews the various theories of particle mixing.

Blending of liquids

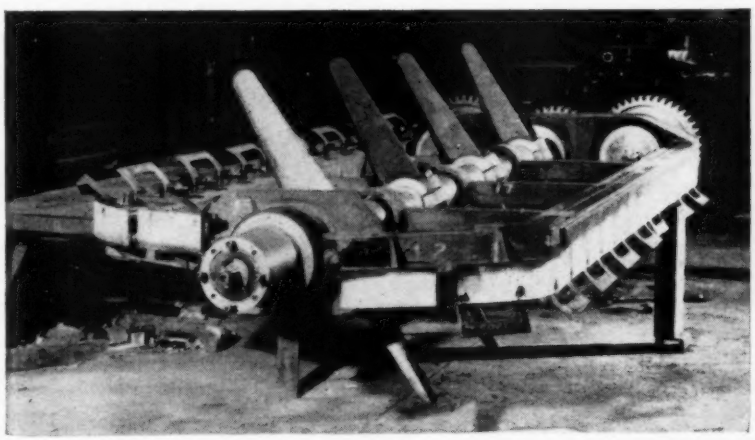
Fox and Gex[1] have recently investigated the factors affecting the time required for complete blending of miscible liquids by means of jets and marine propellers. The results obtained are applicable only to Newtonian liquids of nearly equal density and viscosity.

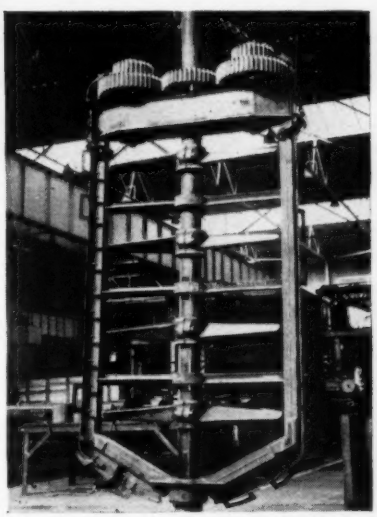
Glycerol, water, hardened and unhardened vegetable oils were used as the liquids, the viscosity ranging from 0.5 to 400 centipoises. The tank diameter varied from 6 in. to 14 ft.,

A CPE Chemical Engineering Review

the propeller size from 1 in. to 22 in., the jet diameter from $\frac{1}{16}$ in. to $1\frac{1}{2}$ in., and the Reynolds Number from 100 to 2.10.[5]

Fully developed turbulence was considered to be established at $Re = 10^4$ for a propeller and $Re = 2{,}000$ for a jet. The variables were changed one at a time, no attempt being made to maintain geometrical similarity. The results were correlated in terms of a ' mixing time factor ' which was found to be a function of the Reynolds Number, analogous to the friction





These two photographs show separate views of a special W. J. Fraser & Co. Ltd. rotating-type agitator for the mixing of high-melting-point greases as installed in 15,000-lb. size vertical jacketed autoclaves. The agitator comprises a central shaft with heavy, flighted paddles rotating in a contra direction to the gate which in turn carries flighted paddles with spring-loaded scrapers in contact with the sides of the vessel for heating purposes. The whole assembly is driven via the central shaft through sun and planet gears mounted on the gate internally in the vessel with an external gear and motor-drive unit.
The vessel is approximately 6 ft. 9 in. i.d. × 8 ft. deep, and the agitator is driven by a 75 h.p. 3-speed electric motor and worm reduction gear unit giving a shaft speed of 48 r.p.m., with a gate speed of 29 r.p.m.

factor in pressure loss calculations. It is suggested that the rate of liquid blending is a function of the flux of momentum M, rather than of the power input, where M is proportional to D^4N^2, D being the impeller diameter and N the speed.

The time of blending by means of a propeller under turbulent conditions is given by

$$t = \frac{f\, y^{\frac{1}{2}}\, D_t}{(D^2N)^{2/3}}$$

where f = mixing time factor.
y = liquid depth.
D_t = tank diameter.
D = impeller diameter.
N = impeller speed.

A corresponding equation is obtained for blending by means of jets. It was concluded from this analysis that any combination of impeller speed and diameter which produces the same momentum flux will give the same time of blending but the power consumption will vary accordingly.

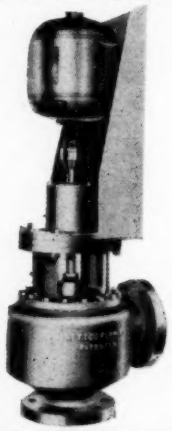
A large propeller at low speed will give the same mixing time as, but use less power than, a smaller propeller at higher speed. The capital cost of the former will, of course, be greater, so in practice a compromise has to be sought.

Experimental data on the blending of low viscosity liquids on a large scale, using side-entry propeller agitators, are also reported by Oldshue, Hirschland and Gretton.[2] The type of blending studied was that in which the liquids are stratified before blending begins and which requires more power than when the second liquid is injected into an initially uniform layer of the first. Three flat-bottomed vertical cylindrical tanks were used, the largest being of 58,000 gal. capacity and the propellers were located 7 to 10° off centre to obtain vertical turnover of the layers.

The liquid used was water and the two layers were produced by floating a layer of hot water on to a deeper one of cold water, suitable precautions being taken to prevent mixing at the interface. Copper-constantan thermocouples were mounted at various levels and connected to a multipoint recorder. It was found that agitation of the lower layer resulted in a gradual erosion of the interface so that the latter moved upwards. As the interface reached each thermocouple in turn the temperature at that level dropped to that of the bulk of the water below the interface. When it finally reached the surface of the liquid the two layers were blended.

Variation of the temperature difference between the two layers showed that the time of blending was proportional to the 0.9 power of the fractional density difference. It was also inversely proportional to the power consumption and proportional to the −2.3 power of the ratio of impeller diameter to tank diameter. The effect of this latter ratio was measured at constant power input and with a liquid depth equal to the tank diameter.

Minimum blending time was found to correspond to a horizontal shaft pointing about 10° off centre, when experiments were made to find the effect of propeller location. It was concluded from this study that the blending of low viscosity liquids is largely a matter of pumping rate and that large diameter low speed impellers give shorter blending times for the same power input than small diameter high speed impellers. Valuable as the results of these experiments are, however, they do not yield a practical means of predicting blending time since the relationships obtained do not give a dimensionally consistent equation. Although it is pointed out that blending is dependent chiefly on pumping rate, no attempt has been made to relate the blending time, for a given volume of liquids, to the discharge capacity of the propeller.



The Nettco 'Flomix' continuous mixer, designed for installation in a pipeline to mix liquids flowing through the line, is now being manufactured in Britain by Stockdale Engineering Ltd. A feature of this type of mixer is that the design provides for repeated dividings, reversings and combinings of the entering flow, coupled with violent mechanical agitation.

'Flomix' mixers have found favour in the United States for scrubbing liquors, an instance of this being the scrubbing of sour gasoline with caustic soda solution. The design can be varied to meet unusual requirements and the photograph shows a standard 'Flomix' body with special adaptor for standard foot-mounted motor.

Liquid-liquid extraction

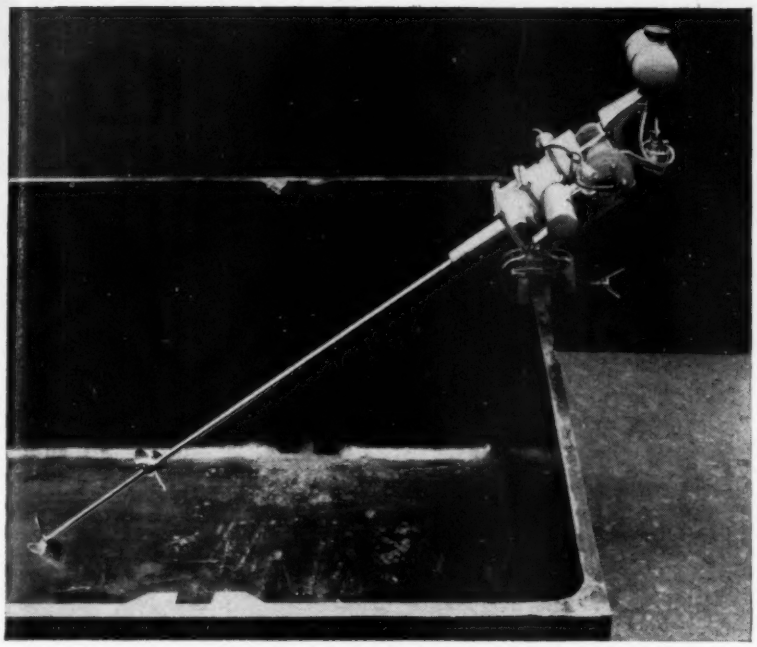
Flynn and Treybal[3] have presented experimental data on liquid-liquid extraction in continuous agitated extractors. They used two dimensionally similar baffled glass extraction vessels 6 in. and 12 in. diam., with a single 6-bladed flat blade impeller having a diameter equal to one-third of the tank diameter. The liquids used were toluene, kerosene, sucrose solution, motor oil and water. Solvent and water were fed in continuously at the base of the tank and withdrawn at the top in such a way that there was no liquid-air interface.

The turbine speed was varied widely and the power consumption, except at very low inputs, was measured by means of a dynamometer. It was found necessary in the absence of a liquid-air interface to increase the degree of baffling beyond the normal in order to produce full turbulence. Benzoic acid was extracted from toluene or kerosene into water, the mixed effluent being allowed to separate and each phase analysed for acid content. Total flow rates were in the range 500-4,000 lb./hr. and phase ratios varied 18-fold.

The stage efficiency was calculated, making allowance for the amount of extraction which took place without agitation, and plotted against the power per unit volume. A single curve was obtained for each liquid system and phase ratio at all flow rates and in both sizes of vessel. It was found that the reactor operates at maximum efficiency only above a certain minimum power input. Usually the stage efficiency increased with the phase ratio in contrast to earlier results with batch extractors. The effect of time on the extraction efficiency in the batch operation of the 12-in. extractor was also investigated. Overall efficiencies were calculated and used to predict the efficiency in a dimensionally similar continuous reactor at the same phase ratio.

Mass transfer in a continuous liquid extractor has also been studied by Overcashier, Kingsley and Olney.[4] The vessel was $14\frac{3}{4}$ in. diam. and several sizes of propeller and turbine were used with and without wall baffles. Tests were also made with spiral-type turbines with stationary deflector rings. In the unbaffled tank impellers were operated with a cover plate in order to prevent vortexing Kerosene containing 0.25% *n*-butylamine was extracted with water, the effluent continuously separated, sampled and analysed.

The stage efficiency was plotted



Completely independent of electrical cables, compressed air lines, or line shafting, the improved and more powerful version of the Kestner petrol-driven portable stirrer has a wide and varied field of application. It is especially suitable for site and pilot-plant work and for use in vessels situated where a power supply is not readily available or when only intermittent or occasional use is envisaged. It is capable of imparting an intense degree of agitation to 300-gal. quantities of fluids similar in viscosity to water and more gentle agitation in up to 1,000 gal. Fluids of higher viscosity can be effectively handled in smaller quantities.

The power is provided by a single-cylinder, air-cooled, 73-c.c. petrol engine, developing 1.3 h.p. at 2,500 r.p.m., and fitted with a totally enclosed oil-lubricated gearbox giving a stirrer shaft speed of 700 r.p.m. Lower speeds are obtained by the use of the throttle adjustment provided. A built-in, self-recoiling, hand-operated starter, sealed to retain lubricant and exclude dirt, is fitted.

The stirrer shaft and opposed-acting propellers are constructed from F.D.P. quality stainless steel and are therefore suitable for use with a wide range of acids and chemicals. Shafts and propellers in alternative materials, including plastics, are also available. A 70° angle of adjustment can be applied to the stirrer shaft by the adjustable bracket and mounting clamp. Truly portable and, therefore, universal in application, the unit weighs only 52 lb., complete with sufficient fuel for a 2-hr. run on full load. Makers: Kestner Evaporator & Engineering Co. Ltd.

against power input, correction being made for that part of the extraction which was attributable to liquid flow. It was found that a propeller in an unbaffled tank could give the same stage efficiency as in a baffled tank, although the power consumption was considerably different. The reduction in power in the unbaffled tank was greater for the smaller propellers and was insignificant for the larger turbines. These results may have been due to the fact that the liquid feed was introduced at the wall of the vessel instead of at the eye of the impeller, as is more usually done.

The data for the baffled tank show that for a given residence time and phase ratio

$$(1-\varepsilon) \propto \frac{1}{Re^{3.2}\,C^{1.37}}$$

where ε = stage efficiency,

$$Re = \text{Reynolds number}\left(\frac{D^2 N \rho}{\mu}\right)$$

$$C = \text{Power function}\left(\frac{P}{\rho N^3 D^5}\right)$$

A few experiments were performed with the 8-in. diam. propeller which indicated that the stage efficiency for a given power consumption increased with the residence time. The effect of phase ratio was only partially investigated but was thought to be minor.

Factors, relating to agitation, affecting the interfacial area of oil-in-water dispersions are the subject of a paper by Rodger, Trice and Rushton.[5] Equal volumes of each phase were used and a 6-bladed flat blade turbine located at the interface, in a fully-baffled cylindrical glass tank. The interfacial area was determined from photographs taken through the base of the tank using a correlation previously developed by Trice and Rodger. The area and the settling time of the dispersion were measured for impellers of various sizes and speeds above those necessary to emulsify the phases completely. In order to obtain consistent measurements of settling time it was necessary to take elaborate precautions to avoid any surface contamination.

The results for each impeller were correlated by plotting the dimensionless product of impeller diameter and interfacial area per unit volume against the Weber number for the system. By taking into account also the ratio of tank diameter to impeller diameter, the kinematic viscosity ratio, the settling time and the fractional density difference, all the data were reduced to a single line. By omitting the settling time an empirical equation was obtained which, although rather less accurate, was of more practical use in predicting the interfacial area available for mass transfer.

The effect of the Weber number on the area is not yet established since Rodger and his co-workers found the area to be proportional to the 1/3 power of We while the results of other workers have indicated that it is proportional to $We^{0.6}$. Increasing the density difference between the phases was shown to increase the area exponentially, while the effect of kinematic viscosity changes was quite small From a comparison of the effects of tank diameter, impeller diameter and speed, it was suggested that a considerable part of the break-up of drops takes place at the wall of the vessel where the direction of flow changes suddenly.

As the energy input was increased phase inversion occurred, producing a water-in-oil dispersion. The inversion took place more readily if the density difference was increased, and it was concluded that in general the impeller should be located completely in the continuous phase. By suitable plotting of the data presented it can be shown that a small impeller at high speed will produce the same interfacial area for a lower power consumption than does a larger impeller at a lower speed.

Gas absorption

Because of the very large vessels which are required in fermentation processes, and partly in order to increase the contact time in smaller vessels, agitators for gas-liquid reactions often consist of several impellers on the same shaft. The effect

of impeller spacing on the flow pattern and absorption coefficient achieved has been studied by Rushton, Gallagher and Oldshue.[6] Fully-baffled tanks of 6 in. and 12 in. diam. were used, air being admitted through an open pipe under the lower impeller in the smaller tank and through a sparge ring in the larger tank.

Experimental runs were made, varying the liquid depth, the number and spacing of the turbines, the power input and the air flow rate. Absorption coefficients were measured for the oxidation of sodium sulphite in water. It was found that when two turbines on the same shaft are sufficiently far apart they behave independently of one another as far as the flow pattern is concerned. When they are brought close together, however, the flows from the two impellers interfere, the power consumption falls, and the resultant flow is difficult to predict, since a mixture of radial and axial flow may occur which is critically dependent on the geometry of the system.

The data obtained show that, in general, at low power inputs dual turbines give a lower absorption coefficient than does a single turbine at the same power input. At high power inputs, however, the effect is reversed, dual turbines usually giving higher coefficients than a single turbine. The degree of improvement of the coefficient depended on the air flow rate and on the impeller spacing, the maximum occurring at spacings too large to be practical. The increase at high power inputs and air flow rates was of the order of 10% for spacings of 2½ D. and up to 25% for a spacing of 7 D. It is concluded from these results that for practical purposes the gain in reaction rate from using multiple turbines is marginal. There may, however, be mechanical considerations which will determine whether the required power input is better supplied by means of multiple impellers or a single impeller.

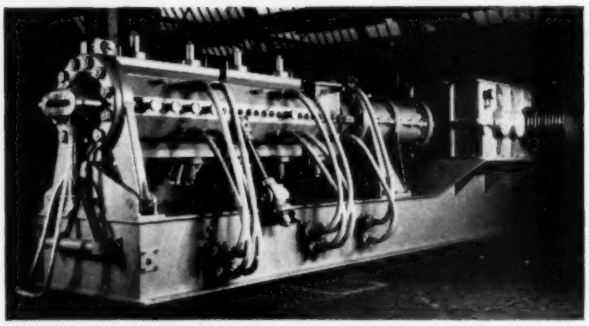
Oxygen absorption in waste treatment by the activated sludge process, using mechanical dispersion, has been studied by Kalinske.[7] He used radial flow turbines having 12 to 24 short, straight blades, and a sparge ring below the impeller to distribute the air uniformly to the inner periphery of the blades. The tank, which was 30 in. in diam., was fitted with baffles and geometrically similar turbines were used in the size range 3 to 12 in. diam. The impeller diameter, speed and air flow were varied and the oxygen absorption efficiency measured, using the copper catalysed sodium sulphite oxidation technique.

The absorption efficiency was found to be proportional to $\frac{V^{3/2}}{S^{1/2}}$

where V = peripheral velocity of impeller and S = air rate per unit peripheral area. The decrease in power consumption with increasing air flow rate was also measured and an empirical correlation presented. Taking into account the power required for air compression as well as for agitation, Kalinske concluded that minimum power consumption was obtained at an oxygen absorption efficiency of 10 to 12%. Whereas porous diffusers usually give efficiencies of the order of 5 to 7%, with mechanical agitation efficiencies of up to 40% can be obtained, but only at the cost of very high total power consumption.

The design of aeration systems for the treatment of biological wastes has also been considered in a paper by Eckenfelder.[8] In the absence of mechanical agitation porous spargers are necessary to give a fine dispersion of air in the liquid. On the other hand, under turbulent conditions at high air rates porous spargers and other devices for producing very fine bubbles give lower mass transfer coefficients than do simple nozzles. Furthermore, mechanically agitated treatment tanks can handle considerably larger air rates than can diffuser-type aerators.

With increasing impeller speed the bubble size decreases, varying inversely as the 3/2 power of the peripheral speed. The hold-up also increases, and with it the total interfacial



The Type P 'Ko-Kneader,' shown here, is used in the plastics industry for the continuous mixing and compounding of thermoplastic and thermosetting materials. Machines of this type are also in use for all types of heavy kneading and mixing processes, such as the dispersion of carbon black and other pigments in stiff media. Lighter types of the 'Ko-Kneader' are also used in the chemical industry for various reaction processes, or for the continuous mixing and granulating of different products suitable for fluidised beds.

Basically, the Buss 'Ko-Kneader' consists of a barrel into which three horizontal stationary rows of kneading teeth are fitted. Inside the barrel runs the mixing worm, which has interrupted flights, the gaps corresponding to the stationary teeth. This allows the mixing worm to rotate and reciprocate at the same time, the gaps in the moving mixing worm passing through the stationary teeth.

The material is fed through the hopper and is carried forward by the worm until it reaches the first circumferential row of kneading teeth. The worm is rotating and still on its forward stroke; that part of the material which is held by the stationary kneading teeth returns between the gaps in the worm into the next space behind the moving flights. In this way the new material continuously fed into the machine is, throughout its passage through the barrel, continuously intermixed and squeezed between the moving and stationary parts of the machine. In effect, each kneading tooth and its corresponding worm flight becomes a mixing machine in itself and the accumulative effect obtained in this way is the explanation for the high quality of mixing that can be obtained.

Special features of the machine include its vertically divided barrel, allowing easy and quick access to all parts of the machine coming into contact with the product; the individually removable kneading teeth, which can be exchanged for blind plugs, hollow teeth or specially shaped teeth to suit individual processes; and the possibility of fitting different types of dieheads and extrusion heads suitable for the processes concerned. Other accessories, such as granulating devices of various types, are available. The machine is marketed in the United Kingdom by Aldersley Agencies Ltd.

area. Rates of air flow up to 20 C.F.M. per sq.ft. of peripheral area have been used and power consumptions up to 0.1 h.p./100 gal. Agitation in biological waste treatment serves not only to maintain the required oxygen level throughout the whole of the liquid but also to break up the flocs of sludge which hinder the transfer of oxygen.

A third paper on the role of agitation in the aeration of activated sludge comes from Oldshue.[9] Data are given from experiments conducted in a vertical cylindrical tank 20 ft. in diam., having vertical baffles, and using flat blade turbine impellers of 48 in. diam. A sparge ring of the same diameter as the impeller was located underneath the impeller and the liquid depth, agitator speed and air rate were varied. The total power consumption for agitation and air compression was calculated for several constant oxygen uptake rates and a constant dissolved O_2 level (2 p.p.m.) and it was found that the total power was at a minimum when the O_2 absorption efficiency was in the range 10 to 20%, thus confirming the results of Kalinske.

The importance of liquid depth in the aeration of activated sludge is emphasised. It is shown that, under conditions of constant tank volume, O_2 uptake rate and dissolved O_2 level, the greater the liquid depth the smaller the total power required. As the liquid depth is increased, the interphase contact time, and hence the gas absorption efficiency, increases while the volumetric rate of air flow decreases. On the other hand, the required air pressure increases and so does the shaft length of the agitator. In practice the liquid depth is limited both for ease of construction of very large tanks, and so that low-pressure blowers can be utilised. In order to deal with large liquid volumes, therefore, multiple agitators have to be installed.

The mechanism of oxygen transfer from air bubbles through the liquid to the suspended solids, in 3-phase systems such as are found in fermentation and activated sludge processes, is extremely complicated and a considerable amount of research will be necessary to elucidate the effects of agitation on the various steps in the transfer. Meanwhile pilot-scale data on the variation of absorption coefficient with agitator power and air flow rate can be used as a basis for the design of full scale installations.

Solution of solids

The researches of Hixson and his co-workers on the mass transfer from a suspended solid to the liquid in which it is being agitated have been followed up by Johnson and Huang.[10] In 1951 Danckwerts proposed a surface renewal theory for the mass transfer in a packed tower, as an alternative to the 2-film theory of Whitman and Lewis. Johnson and Huang have attempted to find out whether the Danckwerts theory could be extended to mass transfer in a liquid-solid system. In order to avoid the continuous change in surface area of suspended particles they cast a ring of the solid under test into a groove in the aluminium bottom plate of a 6-in. diam. glass mixing tank.

A 6-bladed, flat-blade turbine was mounted $3\frac{1}{2}$ in. off the bottom of the cylinder and four wall baffles $\frac{3}{4}$-in. wide were fitted. Five combinations of liquid and solid were selected, including benzoic acid in water, and samples were withdrawn periodically for analysis. The results were correlated in terms of the equation

$$\frac{kl}{D} = K\,Re^a Sc^b$$

in which k = mass transfer coefficient
l = vessel diameter
D = diffusivity
K = a constant for the given system
Re = Reynolds number
Sc = Schmidt number.

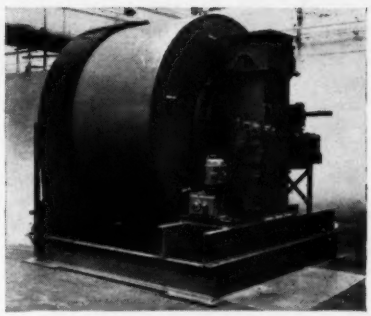
The constant K was found to be 0.924, the exponent a 0.71 and the exponent b 0.50. From these results it follows that the mass transfer coefficient is proportional to the square root of the diffusivity, in agreement with Danckwerts' theory according to which

$k = \sqrt{Ds}$ where s = fractional rate of surface renewal.

Although this result cannot be taken as conclusive evidence that the theory of surface renewal applies to liquid-solid mass transfer it provides nevertheless a useful confirmation of Hixson's earlier work, using a rather different technique. It was found that the presence of baffles decreased the rate of mass transfer under certain conditions, although the effect was negligible when the ring of solid was near to the wall of the vessel.

Mixing of solids

Lacey[11] has reviewed the various theories of particle mixing and has advanced a new theory based on Fick's law for one dimensional diffusion. The field of solids-mixing is one in which experiment lags behind theory and the data available at the present time is insufficient to enable a decision to be made between the theories or to define their limits of application.



The 'Type R' batch blender, the latest addition to the range of Sturtevant Engineering Co. Ltd., is primarily intended for the fine chemical blending of multi-constituent mixtures, but is equally suitable for blending all kinds of materials.

The general design follows conventional lines in that it consists of a rotating drum fitted internally with lifting flights: the whole machine assembly is flameproof and is fitted with reliefs on the non-feed side providing against internal explosion. The illustration clearly shows the feed and discharge side together with the charging and discharging controls which can be automatic and remote.

A notable feature is the provision of sampling ports: by inserting an extraction tube, an operator is able to observe the progress of blending. In the photograph, three sampling ports may be seen on the side of the mixing drum. The machine is obtainable in a number of sizes to accommodate charge capacities of from 10 to 120 cu. ft.

Clearly the predominating mechanism of particle mixing will differ according to the design of the mixer and the mode of action involved, so that different theories may be expected to apply to different types of equipment. From diffusion theory Lacey has deduced that a graph of time versus the function $\log\left(\frac{S^2}{\sin^2 \pi p}\right)$, where S = the standard deviation of the sample and p = the mean composition of the whole mixture, will give a straight line unless there are any regions of poor mixing. This provides a readily applicable criterion by means of which the progress of a solids-mixing process can be followed.

Data on the rate and efficiency of mixing of dry powders in several different types of blender are reported by Gray.[12] The compositions of samples at various positions in the mixer after a given time interval were determined by using a calibrated photoelectric probe which measured the intensity of light reflected from the layer of mixed dark- and light-

coloured particles immediately against the glass window of the probe. The blenders used were of the double cone, V-mixer, rotating drum, ribbon, planetary and muller types. Each blender was tested when mixing 91% of sand (S.G. 2.6 and mainly 65 to 200 mesh) with 9% of ilmenite ore (S.G. 4.3 and mostly finer than 200 mesh).

The rotation of the blender was stopped at intervals and on each occasion the probe was inserted in at least 10 positions. The standard deviation of the readings taken was plotted against the number of revolutions to show the approach to uniformity of composition.

After about 2,000 turns there was no further improvement in the degree of mixing, and it was found that of all the types of equipment tested the ribbon mixer gave the closest approach to uniformity of composition. Good results were also obtained from the V-mixer and the muller, but not from the double-cone mixer of which two sizes, geometrically dissimilar, were used. This confirms the results of Adams and Baker, who found that the double-cone blender was not very efficient when handling solids having different densities.

In a second series of experiments 80% of aluminium oxide (S.G. 4.0) was mixed with 20% of a grade of ilmenite ore having approximately the same particle size and two machines were tested, namely, the twin-shell mixer and the smaller of the two double-cone mixers. In this case the V-mixer gave a more uniform product after 2,000 turns and the standard deviation curve showed that after about 100 turns in the double-cone blender segregation started and the degree of uniformity actually deteriorated, so that the mixture after 2,000 turns was no better than that achieved after only 10 turns.

A third series of runs were made in the ribbon mixer, muller and V-mixer, using precipitated barium sulphate (S.G. 4.3 and mainly finer than 5μ) and a fine grade of ilmenite (90% finer than 40μ). For such a mixture, which was not free flowing and tended to form agglomerates, the most effective mixer would probably be the muller. It is interesting to note, however, that the ribbon mixer again gave the most nearly uniform mixture after 2,000 turns. Such agglomerates as were found in the ribbon mixer became smaller as the blending was continued. The performance curve of the V-mixer is not shown beyond 700 revs., but at this point it is intermediate between the ribbon mixer and the muller in degree of uniformity.

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Welding and Fabrication of High-Nickel Alloys

NICKEL- and cobalt-based alloys developed for special high-temperature and corrosion service are expensive and require careful handling to ensure that the maximum benefit is gained from their use. The behaviour of a metallic material, when welded, will depend not only on the chemical reactivity of its constituent elements, but on its ability safely to absorb the thermal stressing that takes place when a small area of the metal is subject to intense heating. Some of these special alloys undergo a severe reduction in ductility at elevated temperatures, while carbide and intergranular compounds are precipitated if the metal is not cooled quickly.

The precautions recommended with the *Hastelloy* series of high-nickel alloys, to obtain satisfactory welding and fabrication, were recently described and demonstrated by Mr. R. Phillips, of the Haynes Stellite Division of the Union Carbide & Carbon Corporation (U.S.), at a series of five one-day courses held recently at the factory of Langley Alloys Ltd., near Slough, England. It may be recalled that in March we published an article on the properties and applications of the cast *Langalloy* ' R ' series of special nickel-based alloys which have similar compositions and properties to the *Hastelloy* series.

The main points stressed throughout Mr. Phillips' talk were that welding should be as fast as possible so as to reach the critical welding point quickly. Building up heat in the weld area, which is conducive to cracking should be avoided, and the base material and weld should be cooled between each run.

The process used for heavier materials such as the cobalt-base alloys, Mr. Phillips stated, is almost always metallic arc welding, which gives better physical properties. Less carbide precipitation results, however, from the argon-arc process and this process is preferred where the material is going into corrosive service. Pure argon, or helium or argon with 1% oxygen are the recommended shielding gases.

Fabrication

The fabrication of these alloys is somewhat similar to that for stainless steel; however, heavier equipment will be required for forming and shearing. Material up to ¼ in. thick may be sheared; on material thicker than ¼ in., abrasive cut-off wheels are used.

Full annealing is recommended after cold working. Where critical forming is done, intermediate anneals are required. Only by giving a full anneal after forming is the maximum corrosion resistance obtained from these alloys. In cases where it is impractical to give full anneal after forming because of dimensional accuracy or size limitation, the part should be given full anneal when 90% of the forming has been completed, then complete the forming. Mr. Phillips estimated that only about 20% of the chemical equipment manufactured in the United States is fully annealed.

Lining pressure vessels

No enthusiasm was expressed for the lining of vessels with special alloys and it is not recommended except where the corrosive duties are only moderately aggressive. The size of strip that can be used for lining a vessel depends upon the vessel size and pressure, but the largest size that has been used to date is 10 in. wide and 42 in. long. Plug welding has not been found to be a very satisfactory method for lining vessels, due to the danger of radial cracking.

(*Concluded on page* 298)

Heat Transfer from Spiral Tubes

Recent work on a useful but hitherto little-explored subject

IN heat-exchanger equipment it is common practice to have one of the heat-carrying agents flowing in a curved pipe; the Reynolds number (Re) which governs the flow in these conditions may vary over a wide range, from 10^2 or 10^3 for a viscous fluid at moderate temperatures to 10^5 and higher for high-speed gas flow. When fluid flows in a curved pipe, a centrifugal force acts upon the fluid particles and, under certain conditions, a pronounced secondary circulation, of the form shown in Fig. 1, is superimposed on the main flow. Much work has been carried out on this secondary flow, particularly in relation to gas flow in ducts, but there is very little information on the effect of this secondary circulation on the heat transfer from the fluid through the tube walls; an account of recent Russian work[1] on this topic is therefore of interest.

The onset of this secondary circulation was first studied[2] using a coloured fluid introduced into the flow of water in a spiral glass tube. The fluid particles move in a complicated path, and there is little mixing of the two fluids below a certain critical Re; the transition to turbulent motion occurs at a value of Re much greater than that corresponding to the transition in a straight tube. Further work[3] determined this critical value and also the connection between the resistance coefficient for flow in straight tubes and that for curved tubes. The relation between the upper limit of Re and the ratio

$$\frac{d}{D}$$

where d = diameter of the tube and D = diameter of the spiral, is given by

$$\mathrm{Re}_{\text{upper limit}} = 18{,}500\left(\frac{d}{D}\right)^{0.28}$$

Considering the resistance to flow, the ratio

$$c = \frac{f_{\text{curved}}}{f_{\text{straight}}}$$

may be found as a function of the dimensionless quantity

$$\mathrm{Re}\left(\frac{d}{D}\right)^{0.5}$$

Experimental work gives the relation

$$\frac{1}{c} = 1 - \left\{1 - \left[11.6\ \mathrm{Re}\left(\frac{d}{D}\right)^{0.5}\right]^{0.45}\right\}^{\frac{1}{0.45}}$$

which is plotted in Fig. 3. This equation is only valid in the range

$$2{,}000 > \mathrm{Re}\left(\frac{d}{D}\right)^{0.5} > 11.6;$$

below the lower limit the flow is laminar, so that $c = 1$ and the curvature has no effect upon the resistance. This leads to the plotting of the lower limit of Re in Fig. 2, from the relation

$$\mathrm{Re}_{\text{lower limit}} = 11.6\left(\frac{d}{D}\right)^{-0.5}$$

The flow may be divided into three regions by these curves:

(*a*) Below the lower curve, which indicates laminar flow.
(*b*) Between the curves, in which region secondary circulation is important.
(*c*) Above the upper curve, indicating completely turbulent flow.

The only work which appears to have been done upon the effect of the curvature of the pipe upon heat transfer corresponds to very high Reynolds numbers.[4] The work suggests, for $\mathrm{Re} > 10^5$, the equation

$$\alpha_{\text{curved}} = \varepsilon\alpha_{\text{straight}}$$

where α = heat-transfer coefficient

$$\varepsilon = 1 + 3.4\frac{d}{D}$$

The recent Russian work has been concerned with much lower Reynolds numbers, and has been carried out using copper pipe with water and transformer oil as the heat-carrying fluid. The investigation covers a range of Re from 63 to 20,900, and Fig. 4 shows the relation between the resistance coefficient for pipe flow and the corresponding Re. For all the configurations of pipe spiral tested and values of $\frac{d}{D}$ the results are covered by the single line; the transition from laminar to turbulent flow occurs smoothly, as opposed to the abrupt transition in the flow in straight pipes.

Experimental values of the heat transfer trials are shown in Fig. 5; for the various configurations of piping, the results fell within the shaded

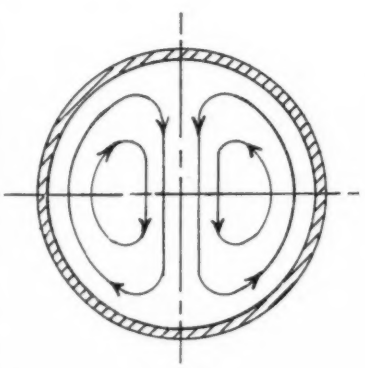

Fig. 1.

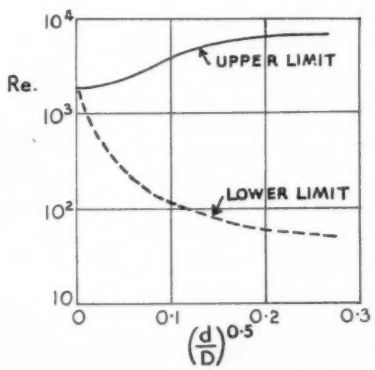

Fig. 2.

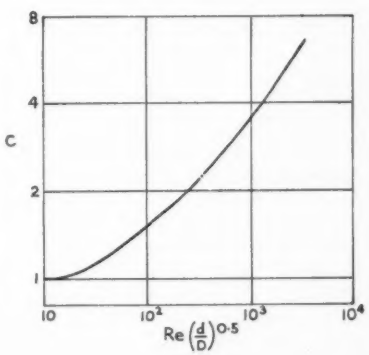

Fig. 3.

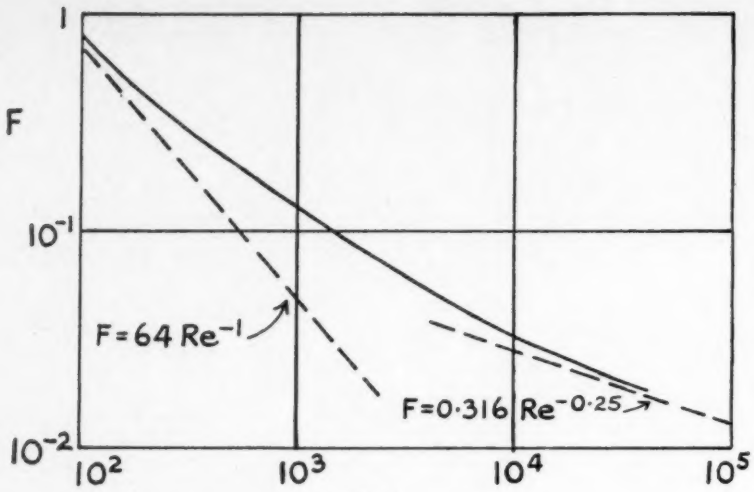

Fig. 4.

area, not more than 7 to 10% from the values calculated from turbulent motion in a straight pipe

$$Nu_{mean} = 0.021\ Re_{mean}^{0.8}\ Pr_{mean}^{0.43} \left(\frac{Pr_{mean}}{Pr_{spiral}}\right)^{0.25}$$

where the suffix mean refers to the mean temperature of the fluid and the tube walls.

Summarising this work, therefore, the equations of heat transfer for laminar flow cannot be applied to flow in which secondary circulation occurs, and it is better in such cases to determine the heat-transfer coefficient from conditions corresponding to flow in a straight pipe at higher Reynolds numbers.

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[2]G. I. Taylor, *Proc. Roy. Soc.* (London), 1929, **A124,** 243.
[3]G. M. White, *Ibid.*, 1929, **A123,** 645.
[4]D. Jeschke, *Z.D.V.I. Ergangzungsheft*, 1925, (1), 24.

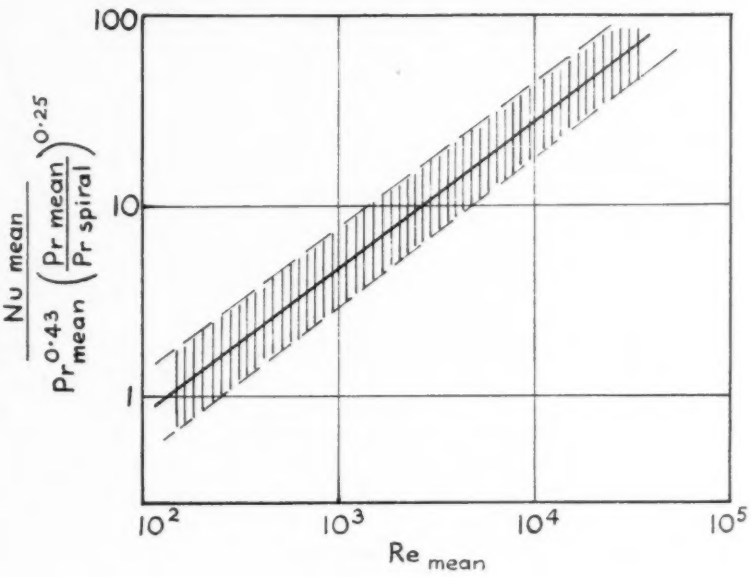

Fig. 5.

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Stratford House, 9 Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

Fluid-bed Reactor

A pair of 4-ft.-diam. fluid-bed reactors suitable for ore roasting on a tonnage basis has been installed at the pilot-plant laboratory of Battelle Institute, Columbus, Ohio.

The two reactors can roast ores in one or two stages in either oxidising or reducing atmospheres. They accept either solid or slurry feed.

The roasters will be used in flexible, pilot-plant-scale experimentation preparatory to the actual design of full-scale ore-treatment plants. In this way they will complement present Battelle fluid-bed reactors used in bench-scale and small-scale laboratory research. The reactors are equipped with instruments for measuring and controlling such important variables as temperature, pressure, gas flow and gas composition.

The new units are believed by Mr. F. M. Stephens, chief of Battelle's extractive metallurgy group, to be the largest roasters of their kind available for research on behalf of industry and government.

Fluid-bed reactors or roasters are assuming increased importance in ore treatment as the need for using lower-grade ores and more chemically complex ores accelerates the trend from physical to chemical ore treatment. Roasting which, for instance, may convert a sulphide ore to an oxide or sulphate, makes the ore more amenable to leaching procedures. Fluid-bed reactors, which provide close control of both temperature and atmosphere, yield a uniform end product.

Principles of Refining
LUBRICATING OIL
(Part I)

By A. Doll-Steinberg, B.A.

With the greatly increased demand for lubricating oils of all grades has come a greater knowledge of how to obtain the various properties required for particular applications and a corresponding complication of the refining processes involved. This article approaches the subject methodically, first discussing the different lubes, their origins and properties, and leading on to actual production methods.

THE only significant source of lubricants is the residue remaining after the distillation of the lighter components, gasoline, kerosene and gas oil from crude petroleum. Satisfactory synthetic lubricants can be made for certain purposes, but petroleum oils are the only materials which possess all the properties required and which can be produced in the quantities and with the economy required by modern industry.

Crude oils

Any topped crude will consist of the following classes of compounds; the proportions will depend on the individual crude:

(1) Asphaltic bodies.
(2) Resins and chemically unstable materials, and colour bodies.
(3) 'Low viscosity index' (V.I.) constituents, known as naphthenics and characterised by their relatively large viscosity-temperature variation.
(4) 'High viscosity index' constituents, known as paraffinics and characterised by their relatively small viscosity-temperature variation.
(5) Waxes.

The boundaries of these classes are not at all clearly marked. Each class consists of a large number of compounds showing a gradation of molecular structures, and hence of properties, into the next class.

Thus the waxes consist of molecules of large paraffins and of naphthene rings attached to long alkyl chains. The paraffinics consist of molecules of one to three naphthene rings attached to long alkyl chains. The naphthenics comprise molecules containing upwards of three naphthene rings attached to alkyl chains, and molecules containing

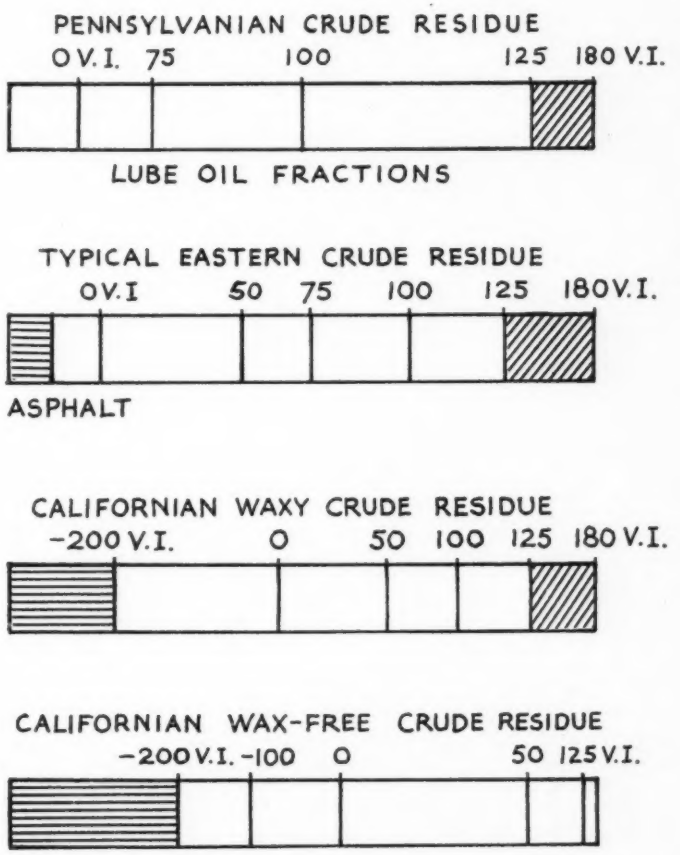
PENNSYLVANIAN CRUDE RESIDUE
0 V.I. 75 100 125 180 V.I.
LUBE OIL FRACTIONS
TYPICAL EASTERN CRUDE RESIDUE
0 V.I 50 75 100 125 180 V.I.
ASPHALT
CALIFORNIAN WAXY CRUDE RESIDUE
-200 V.I. 0 50 100 125 180 V.I.
CALIFORNIAN WAX-FREE CRUDE RESIDUE
-200 V.I. -100 0 50 125 V.I.

Fig. 1 (after Ter Meulen). Distribution of components having given V.I.s in representative American crude residues. The area between two V.I. ordinates is a measure of the percentage of constituents of the residue having V.I.s in the enclosed range. Constituents of similar V.I.s from different crudes are not necessarily of the same chemical constitution.

one to three or more aromatic rings. The resins consist of more highly condensed aromatic compounds and the asphalts are still more highly condensed.

The relative proportions of these classes and the distribution of the substances constituting the classes within them varies greatly with the individual crude. For example, the low V.I. constituents from a bad lubricating oil base (*e.g.* an American coastal crude) will be very different in structure from those derived from a good lubricating oil base (a paraffinic crude, *e.g.* Pennsylvanian), although their physical properties will be similar in many respects.

Lillard, Jones and Anderson[1] give the results of fractionation of crude American coastal (poor lubricating base) and mid-continent (fairly good base) residua, using a method of percolation over silica gel to obtain the fractions. The fractions were identified using infra-red spectroscopy and other methods and divided into the five following main classes, whose V.I.s were determined:

A ... Paraffinic naphthenes.
B ... Polycyclic naphthenes.
C ... Single-ring aromatics.
D1 ... Two-ring aromatics.
D2 ... Three-ring and higher aromatics.

The results for the two oils are as follows:

	Crude coastal		*Mid-continent*	
	Vol.%	*V.I.*	*Vol.%*	*V.I.*
A ...	52	102	60	124
B ...	14	–60	10	47
C ...	7	41	8	95
D1 ... }	27	–85	12	38
D2 ... }			10	–81

This illustrates the difference in the constitutions of the V.I. groups in the different crudes.

Lubricating oils

The lubricating oil base is refined to eliminate the undesirable constituents, but the constituents undesirable in one product may not be undesirable or may even be desirable in another oil. The important properties of a lubricating oil are:

(*a*) The viscosity at a given temperature.
(*b*) The variation of viscosity with temperature—the V.I. (viscosity index) and V.G.C. (viscosity gravity constant) are measures of this variation.
(*c*) The temperature at which solidification of waxes begins to interfere with the lubricating properties of the oil—the pour point.
(*d*) Stability to oxidation—various standards.
(*e*) Carbon residue—various standards.
(*f*) Flash point, demulsibility and other properties of importance in special cases.
(*g*) Colour—for commercial reasons.

Asphalts and resins are considered undesirable in almost every case, as their presence produces oils of poor colour, stability and viscosity-temperature characteristics. The desirability of the naphthenics and waxes varies both with the oil stock and with the service for which the lubricating oil is destined. The paraffinics are almost in every case desirable.

It is more difficult to generalise about the naphthenic class than about the paraffinic class, but naphthenics, irrespective of their chemical properties are characterised (really, defined) by their lower V.I.s and show ready solubility in solvents such as furfural, nitrobenzene, phenol, aniline and chlorex. Naphthenics tend to have lower stability than the paraffinics, but their stability varies with the crude stock from which they are derived. The instability to oxidation of a naphthenic extract will depend on the proportion of condensed aromatic compounds it contains, so also will the carbon-forming tendencies, colour and flash point.

The paraffinics are characterised by their high V.I.s and low solubilities in furfural and the other solvents mentioned above. They have a high degree of oxidation stability, low-carbon-forming tendency, good colour and high flash points.

Measures of 'paraffinicity' and 'naphthenicity'

Measures of the degree to which a given oil has the characteristics of these classes are provided by the viscosity index, the viscosity gravity constant, the refractive index and by various chemical tests.

The V.I. for a given oil is obtained by comparing its viscosities at two reference temperatures with those of two standard oils. It gives only a measure of the variation of viscosity with temperature, a high V.I. corresponding to low variation and *vice versa*. Indications of the other properties of the oil can be obtained from the value of the V.I., but especially at low V.I.s it may be impossible to predict anything further (*e.g.* stability) from a knowledge of this quantity alone.

The V.G.C. is a quantitative measure of the relationship between S.G. and viscosity, and paraffinicity, paraffinics having low S.G. for a given viscosity and thus low V.G.C., and naphthenics having the opposite property. The V.G.C. provides a better measure of the (undesirable) aromatic content than does the V.I.

The refractive index for the constituents of a given crude is lower for the paraffinics fraction than for the naphthenics fraction.

Table I. Effect of Phenol Extraction on Distribution of Compound Types in Mid-Continent Medium Motor Oil[1]

Yield, volume %		*Approximate distribution, vol. %*			*Estimated compound-type removal (based on extract)*
Compound class	*Average V.I.*	*Feed* 100	*Extract* 17.8	*Raffinate* 89	
A	124	60	21	69	6
B	47	10	9	11	16
C	95	8	10	7	22
D1	38	12	14	13	21
D2	–81	10	46	Approx. 0	82

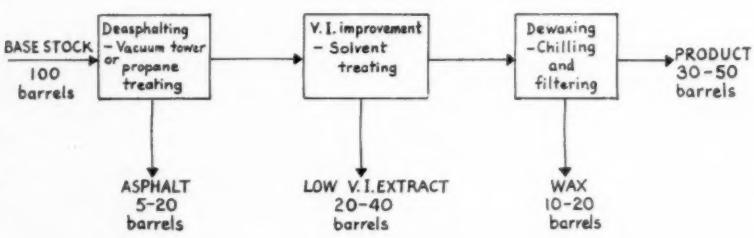

Fig. 2. Representative yields from the main stages in the refining of a typical crude residue for lube oil production. The refining of a typical distillate stock differs in that no de-asphalting is necessary. The product may be clay-finished and blended with other lubes and with special additives. In some applications the product may be suitable for use without further treatment.

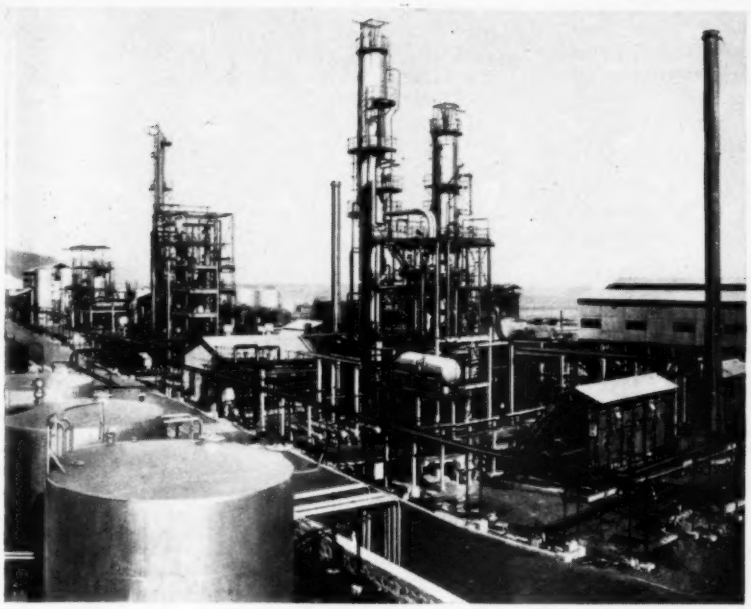

Fig. 3. A complete lubricating oil plant in a Canary Islands refinery showing, in the centre, the two-stage crude distillation unit. The vacuum tower produces the lube distillate stocks which are charged to the solvent-treating unit (*next in line to the left*). **Also shown, beyond the solvent-extraction plant, are the solvent dewaxing and clay finishing units. The refinery also has a propane de-asphalting unit for the production of high-viscosity lubes from heavy residua.**

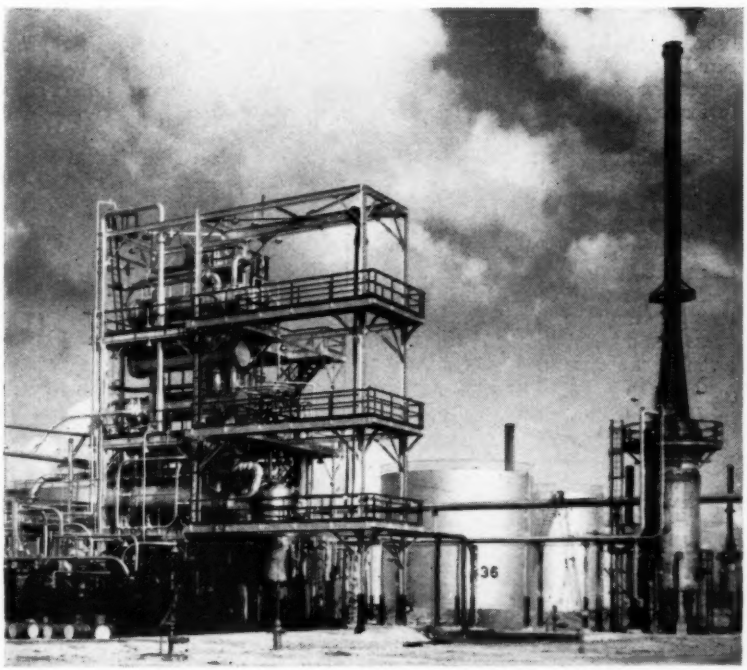

Fig. 4. A propane de-asphalting unit at Fawley—England's largest refinery. This unit treats a heavy residuum from Middle East crude, with a design capacity of nearly 3,000 bbl./day.

It is possible to follow the extraction of a given crude using any of these quantities as a measure of the degree of separation. The R.I. and V.G.C. are more nearly linear properties than is the V.I., but all three are usually considered to be linear (*i.e.* they are assumed to obey the lever rule). In the case of fractions of a given crude, improvements shown by V.I., V.G.C. and R.I. will be related to improvements in colour, stability etc. It is, however, in many cases meaningless to compare these quantities for different crudes or products derived from different crudes.

Selection of crudes

The results given by Lillard, Jones and Anderson for the extraction of mid-continent medium oil using phenol (see Table 1), indicate that this solvent extracts most selectively the highly condensed aromatic constituents and it is reasonable to assume that the results will hold qualitatively for other commercial solvents. Thus it can be seen that a crude, whose low V.I. constituents are mainly polycyclic naphthenes, *e.g.* the coastal crude, can be made to yield a lube oil having satisfactory oxidation stability etc., but it is comparatively uneconomic in yield loss and solvent ratio to produce a high-V.I. oil from such a crude.

Although motor lubrication demands oils having high V.I.s, low pour points, high oxidation resistance and low sludge- and carbon-forming tendencies, for which combination a careful selection of crudes is necessary for economic production, there is also a demand for lower-grade oils and for low-V.I. oils.

Thus industrial oils used for surfaces operating at low temperatures are not exposed to oxidising conditions or to large fluctuations of temperature. For such purposes only moderate stability and low V.I. are required.

Transformer oils and refrigerator oils should be of low V.I. and good stability. These can be manufactured from oils such as the coastal crude mentioned earlier, after extraction to remove aromatics.

On the other hand, turbine oils must have high V.I., high oxidation resistance and low emulsion-forming tendencies. For these oils, acid and earth treatment of highly extracted raffinates is necessary.

Refining methods

The refining of lubricating oils in most instances requires the removal of asphaltic bodies, resins, highly condensed aromatic constituents having

low stability and low V.I., and waxes.

Sulphuric acid treatment followed by naphtha dewaxing was previously the only method used for refining lubricating oils. This process has the advantage that it removes asphalts, resins and unstable and colour bodies in one operation. However, no marked improvement in V.I. results and there are the disadvantages of difficulty of control, formation of undesirable compounds in the oil such as sulphonated compounds and polymers, the loss of oil to acid sludge and the problem of the disposal of the sludge. Sulphuric acid refining plants exist in the U.S., but no new ones are being built.[2] Owing to the fact that the refineries in Britain are nearly all post-war and since they treat mainly Middle East crudes which are of poor lubricating oil quality, sulphuric acid refining is not used, although sulphuric acid treatment may follow solvent refining in some cases for the production of special oils.

The modern refining of lubes involves the use of large quantities of solvents, and economic operation of these processes depends on achieving almost 100% recovery of solvents. Thus, although the applicability of solvent extraction was discovered by Edeleanu at the beginning of this century, it was not until about 1930, when effective methods of solvent reclamation had been developed, that it could be applied on any appreciable scale to the manufacture of lubricating oils. For the same reason, the use of the modern dewaxing solvents dates from the same time.

The removal of asphalt from the heavier stocks previously could be done satisfactorily only with sulphuric acid. Removal as residue in distillation was difficult owing to the fact that very high vacua were unattainable, leading to high skin temperatures in the stills and cracking of the valuable high-viscosity components and also due to the considerable entrainment of the involatile asphalt that occurred. This stimulated the development of de-asphalting methods using precipitative solvents, mainly propane but also some alcohols. Recently, improvements in high-vacuum distillation techniques, including the use of crinkled screens to eliminate entrainment, have made distillation competitive with propane de-asphalting.

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[1]Lillard, Jones and Anderson, *Ind. Engg. Chem.*, 1952, pp. 2623-2631.

[2]O.E.E.C. report, ' Oil Refining and Drilling in the U.S.A.', Organisation for European Economic Co-operation, Paris, 1952.

In the second and concluding part of this article, which will appear in a forthcoming issue, the author will go into further details of the refining methods available, discussing solvent extraction and the selection of the solvent, dewaxing procedure and finally reviewing the sequence of operations.

RECENT PUBLICATIONS

Chemical products. Joseph Crosfield & Sons Ltd., Warrington, have published a well-illustrated, comprehensive booklet summarising the complete range of their chemical products. Separate sections deal with sodium and potassium silicates, sodium metasilicate and other alkaline cleaning agents, sodium hydroxide (caustic soda), ion exchange materials, silica gel and other chemical products.

Transformers. Three new publications from Hackbridge & Hewittic Electric Co. Ltd., Walton-on-Thames, Surrey, deal with forced-cooled transformers up to the largest sizes and voltages, naturally cooled distribution transformers up to 1,000 kva., and small low-voltage transformers 100 watts to 5 kva. respectively. Photographs of equipment and installations illustrate the technical details given.

Heating mantles. A new illustrated catalogue of laboratory heating mantles has been issued by Isopad Ltd., Barnet By-Pass, Boreham Wood, Herts. New items which have been added to their range include micro mantles for flasks from 5 to 50 cc. and multi-size control units.

Engineering data. Talbot Stead Tube Co. Ltd., Green Lane, Walsall, have published a booklet of useful data for the benefit of users of their steel tubes and bars, which is intended to present in compact form the data most commonly required. As well as extracts from relevant British Standards, the booklet includes a section on standard tolerances, weight lists and steel tables.

Fire prevention. The June issue of the *Fire Protection Bulletin*, published by the Fire Offices' Committee, Fire Protection Association, 15 Queen Street, London, E.C.4, offers advice to factory managers on checking fire precautions in their factories.

Organic chemicals. British Industrial Solvents, a division of The Distillers Co. Ltd., Devonshire House, Mayfair Place, Piccadilly, London, W.1, have published ' Bisol Organic Chemicals,' a handbook providing up-to-date technical information about their growing range of solvents, plasticisers and other products. Details are given of the properties, specification, methods of testing, commercial information, storage handling and uses for each product. Appendices supply additional technical information.

Oil refinery planning. The American Oil Co.'s new refinery at Yorktown, Virginia, is the subject of a 16-page booklet just published by the M. W. Kellogg Co., 711 Third Avenue, New York 17, N.Y. It describes the refinery in full with detailed sections on the major areas, including the combination unit, product transfer facilities, utilities and effluent treating facilities. It shows how the Kellogg design resulted in a plant with a compact but not cramped process area which could be easily expanded. This was done by combining an in-line design for the process area with a straight-line process flow in the layout of all facilities. Flow charts and illustrations visually supplement the text throughout the brochure.

Welding processes. Two recent pamphlets from Quasi-Arc Ltd., Bilston, Staffs, describe the *Fusarc* automatic welding equipment and the new *Fusarc*/CO_2 automatic arc-welding process respectively. The electrode used for the latter process consists of the patented type of continuous covered electrode with a newly developed type of covering, and this is used in conjunction with a carbon dioxide shield.

By-pass purification of lubricating oil and other liquids is the subject of a report available from Sharples Centrifuges Ltd., Tower Works, Doman Road, Camberley, Surrey. It comprises principally a mathematical treatment of the problem of the by-pass purification of lubricating oil as practised, for example, in diesel engines, machine tools etc. Following from this there is a discussion of the particular case of the batch purification of liquids and a comparison of the effectiveness of circulatory batch purification with two-vessel batch purification. Finally, and leading from the foregoing, mention is made of the optimum throughput for operation of a centrifuge or, in fact, any type of clarifying purifier.

INVESTIGATION INTO THE MANUFACTURE OF

Pulp Products from Poplar

By John Grindrod

Little used up to now, poplar is one of the most common tree species in the Prairie Provinces of Canada and a study has recently been made by Arthur D. Little Inc., the United States industrial research and marketing consultant firm, for the Manitoba Department of Industry and Commerce into the possible utilisation of the province's large stands of this species. As a result of these investigations a 116-page report has been drawn up which envisages the use of poplar for the manufacture of newsprint, corrugated board, hardboard and insulating board as well as for lumber and plywood. Four potential manufacturing projects representing a total investment of $38 million are listed as feasible.

ACCORDING to most recent forest surveys there are 20 million cords of accessible hardwood on Crown lands in Manitoba, plus about 470,000 cords on private or settler land. Of this, it is estimated that 90% is poplar, mostly occurring as aspen, the rest being black poplar. The non-inventoried agricultural land contains an estimated one million cords of poplar.

The industrial complex proposed in the Little report consists of a large core industry, such as a newsprint mill or a building-board mill, with satellite industries grouped nearby. The latter would include plants for making plywood or lumber out of the better grades of wood. Mill sites are available in several parts of the province, though the best ones are in the northern sections. In the Grand Rapids and Dawson Bay areas there is sufficient wood to support such a mill, and it is considered that transport costs are low enough to enable a Manitoba mill to send its products as far as New York and still return a profit. Although power, fuel, and waste disposal present certain minor difficulties at present, it is not thought that they offer major obstacles to such a proposed mill. The low wood costs are particularly attractive and the production processes recommended are thought to take full advantage of the cost differential between poplar and the more valuable softwoods.

Poplar as a raw material

In the pulp and paper industry, poplar is desirable for many processes because of its light colour, ease of pulping and fast growth rate. It is a favoured pulpwood for the soda process and it can be pulped by any of the commercial methods, generally giving a good yield, colour and bleaching characteristics. The drawbacks to the use of poplar in the pulp and paper industries are short fibre length, susceptibility to rot and a tendency to sink, when it is left in water for prolonged periods. The fibre length of between 1.0 and 1.15 mm. results in a low-strength paper compared with spruce and jack pine, whose fibres are three times as long.

With few exceptions, however, the pulp and paper industry considers hardwoods as inexpensive fillers, though there is some disagreement as to how much poplar can be added to various grades of paper without significantly downgrading the end product. There seems to be general agreement that in newsprint between 6% and 10% of the furnish can be in the form of poplar groundwood or semi-chemical pulp without impairing quality. Beyond the 10% level, most producers find a reduction of brightness, strength and opacity. In fine papers, poplar can represent as much as 85% of the furnish, usually as a bleached chemical pulp, although semi-chemical pulps have recently come into wider use.

Corrugated board can be made with 100% poplar furnish, prepared either from chemical or semi-chemical pulps. Similarly, insulating board and hardboard can be manufactured with up to 100% poplar groundwood or semi-chemical pulp as the furnish. For the manufacture of paperwood, tissue and magazine papers, a furnish containing upwards of 50% poplar chemical or semi-chemical pulp can be used.

Logging scene at Pine Falls, Manitoba.

Planning the plant

One of the most logical industrial complexes based on poplar would be, according to the Little report, one producing hardboard, insulating board and plywood. The advantages of such

a complex would stem from complete wood utilisation, economies in selling and distribution and reduced costs for power and overheads.

Because of its flexibility, Arthur D. Little Inc. recommend the wet-forming/dry-pressing process for the manufacture of hardboard and insulating board. Because of the uncertain availability of low-cost waste wood in Manitoba, they have assumed that poplar logs would be used as the raw material, the yield of both hardboard and insulating board being taken at 80% of the dry bark-free wood charged to the operation. This yield is low compared with that for a regular groundwood operation used for pulp manufacture because of fibre loss resulting from the trimming of rough edges. The presence of cured resin prevents the re-use of this material.

Details of process

In such a process the logs are first debarked and fed to the chipper, oversized chips being screened out and recycled through the chipper. From the chip silos, in which about two days' supply is kept, the chips move by conveyor belt to the continuous cooker, where they are steam-cooked under pressure. The cooked chips are fed directly to the disc refiners where they are converted into pulp. This is held up in stock chests and then washed in a rotary filter washer using white water. Leaving the washer at about 10% consistency, the pulp passes through a re-pulper to remove fibre bundles and then to a consistency regulator, where the stock is diluted to 5%. The stock is then fed to the forming machines from a tile stock chest and head box to which the chemicals, calculated as 1% urea formaldehyde resin, are added continuously.

For this process, Littles assumed that two 4-ft.-wide Fourdriniers, operating at about 25 ft./min., would be used. Press rolls at the end of the Fourdriniers would help to reduce the water content to about 60% and a wet saw would cut the mat to approximately 16-ft. lengths for feeding to the oil-fired, 8-deck drier, which would reduce the moisture content of the mat to about 3%. On leaving the drier, the board would be sent through a double-pass trimmer, the shavings and dust being re-cycled through the pulping operation.

Insulating board and hardboard manufacture

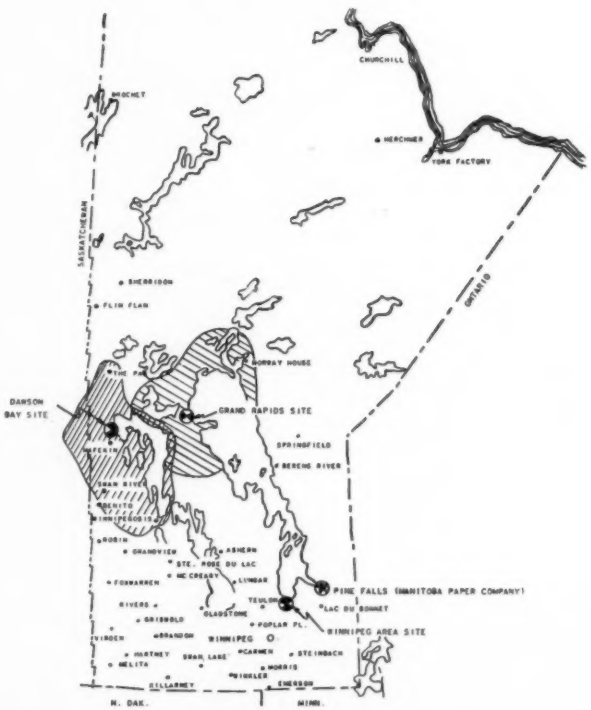
For insulating board manufacture the boards would then go to pre-wetting rolls, through a paint machine, then through a steam-heated coating drier, passing through a double-pass trimmer for cutting to final size or to be cut to approximate size for trimming in a tile machine.

In the manufacture of hardboard, an automatically fed and unloaded 8,300-ton hot hydraulic press, with its own steam supply, operating at about 500°F., would handle 4 ft. × 16 ft. boards in 20 openings. After fan-operated cooling, the boards would pass through a series of hot-oil dip tanks and then to a tempering oven, where they would be held for two to three hours, passing on to a humidifier, where they would be conditioned to about 6% moisture content.

Newsprint and corrugating board

Also regarded as favourable in the Little report is a complex based on the production of newsprint, corrugating board and lumber. Operation of the integrated newsprint-corrugating mill process is based on a newsprint furnish consisting of 63% regular spruce groundwood, 30% poplar neutral sulphite semi-chemical pulp and 7% long-fibre kraft or sulphite. This furnish is thought to be consistent with what is now being used by at least one large commercial operation. It is believed that when more than 30% neutral sulphite pulp from hardwood is used with groundwood, opacity characteristics fall off in the finished newsprint product. In addition to data on the chemi-groundwood process (log cooking), Littles prepared economic estimates, including investments and operating costs, for the newer neutral-sulphite-chip process, because of the growing interest of the newsprint industry in it. Discussions with outside concerns had indicated that there was a definite future trend toward the adoption of semi-chemical pulp made by the cooking and disc-refining of chips, an interest resulting from possible investment savings and easier material handling and grinding operations.

For the integrated manufacture of 300 tons of newsprint and 100 tons of corrugating medium a day, with 6% moisture, a poplar yield of 85%, based on dry debarked wood to the digester, was assumed for the chemi-groundwood process, and a spruce pulp yield of 95%, based on moisture and bark-free wood, was assumed for the groundwood operation. The above yield figures were arrived at from the assumption that poplar and spruce



Potential pulp and paper mill sites in Manitoba.

both weigh 4,400 lb./cord and that the moisture and bark contents are about 50% and 10% respectively, of the raw wood.

For a newsprint furnish of 30% chemi-groundwood pulp and 63% groundwood pulp about 99 cords of poplar and 187 cords of spruce are required for the production of 300 tons of newsprint per day. About 110 cords/day of poplar is needed for the production of chemi-groundwood pulp for 100 tons/day of corrugating medium. Thus, the total poplar requirement for the integrated operation is about 209 cords/day.

Chemi-groundwood pulp production

In the production of chemi-groundwood pulp from poplar the whole log is debarked and cooked with neutral sulphite liquor, in the preparation of which sulphur is usually burned and the resulting sulphur dioxide absorbed in an aqueous solution of soda ash. The digested logs are then ground to produce crude pulp, the pulp slurry being pumped to screens to remove fibre bundles and coarse-wood particulates. The pulp is screened with rotary-type screens and thickened on vacuum deckers, the stock from which is directed on to a paper machine, where newsprint or corrugating medium is formed. Paper leaving the machine is further processed through finishing operations.

Spruce groundwood is prepared by the direct grinding of debarked logs to produce crude pulp, which is screened to remove fibre bundles and coarse-wood particulates. After screening, the pulp is thickened and washed with vacuum deckers. The recovered pulp slurry is adjusted to the desired concentration for application on the paper-forming machines.

Semi-chemical and groundwood process

Almost identical with the chemi-groundwood process, the semi-chemical and groundwood process differs only in that chips are used instead of logs. The poplar chips are digested by a rapid-cycle pressure technique, the chips being impregnated with neutral sulphite liquor, drained and then digested so as to achieve maximum utilisation of the cooking liquor. The digested chips are passed through dewatering presses, which remove excess cooking liquor in a concentrated form for re-use and accomplish partial defibration of the cooked chips. The expelled chips are re-slurried with water and passed through a series of double-disc refiners for further partial refining. For final refining the pulp is passed through a secondary set of double-disc refiners. The refined pulp is then screened, cleaned and pumped to the paper-forming machine. Regular groundwood pulp is manufactured in a similar manner, except that cooking is not required and the preliminary dewatering presses are eliminated.

Economics

The investment for a hardboard and insulating board plant with a daily capacity of 300,000 sq. ft. of product is estimated by Arthur D. Little at $7.5 million. The hardboard and insulating board mill, with annual sales of about $6 million, would earn about $2,133,000 before taxes and $1,087,000 after taxes. The return on investment for this plant would be 15% and the plant payout is calculated at 4.3 years.

A newsprint mill with a daily capacity of 300 tons of newsprint and 100 tons of corrugating board would require an investment of approximately $30 million. The net profit after taxes is estimated at $2,344,000 with a return on investment of about 7.8%.

An appropriate plywood mill is estimated to require an investment of $775,000 to give a return of 6.3%, while a suitable sawmill would require an investment of $25,000 to $30,000 to yield 12.1%.

Technology Notebook

Chemical engineering fellowship

A graduate fellowship in chemical engineering has been established at Massachusetts Institute of Technology. This, the first industrial fellowship in chemical engineering at M.I.T. to be specifically without any restrictions as to nationality of the recipient, was established by Scientific Design Co. Inc., New York, N.Y.

Research laboratories nearing completion

Work is nearing completion on the fundamental research laboratory which the Triplex group of companies is establishing at Holly Grange, Balsall Common, Warwickshire. The laboratory will include laboratories for *x*-ray diffraction and electron microscopy. There will be a physical chemistry laboratory, an optical laboratory, a thermodynamics laboratory, a mechanical properties laboratory, an instrument and equipment workshop and a reference library.

Powder metallurgy joint group

The Councils of the Iron and Steel Institute and of the Institute of Metals have formed a powder metallurgy joint group, the objects of which will be to study the science, technology and practice of powder metallurgy.

Cryogenic engineering

The 1957 Cryogenic Engineering Conference has been planned for August 19, 20 and 21 in Boulder, Colorado. Topics already planned include cryogenic process—liquefaction cycles, purification of gases, distillation, fluid flow, catalysis; cryogenic equipment—dewars, pumps, expansion engines, heat exchangers; cryogenic properties — mechanical, electrical, thermal, vacuum insulation, powder insulation; and cryogenic applications—expansion engines and turbines, cryogenic fuels and oxidants, bubble chambers.

Fellowship award

The Corday - Morgan Commonwealth Fellowship for the academic year 1957-58 has been awarded to Dr. E. A. Magnusson, Teaching Fellow in the School of Applied Chemistry at the New South Wales University of Technology, Australia. During his Fellowship Dr. Magnusson is to carry out an investigation of the theoretical basis of chemical bonds, with special reference to inorganic complexes, under the supervision of Prof. D. P. Craig, in Prof. C. K. Ingold's department at University College, London.

Paper technology

The paper-making equipment which was presented last year to the paper-making section of the Textile Chemistry Department of the Manchester College of Science and Technology by the Reed Paper Group includes a Wennberg electrically heated, rotating autoclave specially designed for making paper pulp on the pilot scale. This can be used either for demonstrations with regular raw materials, such as wood, cotton rags or straw, or for research on any vegetable raw material. It will treat about 2 kg. at a time. A disintegrator and strainer on the same scale are used for breaking up the pulp and removing uncleared fibre bundles.

★ Personal Paragraphs ★

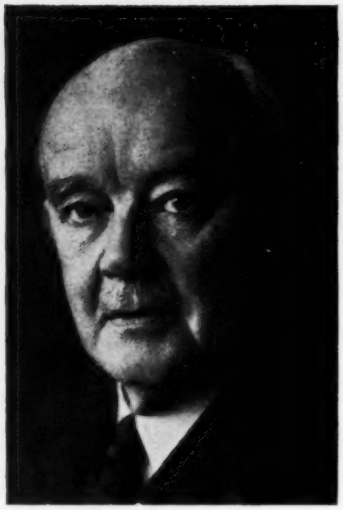
★ **Sir Alfred Herbert,** K.B.E., founder and chairman of Alfred Herbert Ltd., died on May 26. He was 90. The son of a Leicester farmer, he was to have been a parson, but interest in local engineering eventually led to persuading his father to let him become a mechanic. From a 5s.-a-week apprentice he became the founder of what is generally regarded as the largest machine-tool organisation in the world, an organisation which now has four factories, employs some 5,500 people and has either an associate company or an agent in 48 other countries. Sir Alfred was knighted in 1917 for his war-time work at the Ministry of Munitions, in which he was Deputy Director-General and subsequently Controller of Machine Tools. He was a former president of the Machine Tools Trade Association and, for the past 52 years, president of the Coventry Engineering Society. Sir Alfred was an Officer of the Legion of Honour and an Officer of the Order of St. Leopold (Belgium).

★ **Mr. G. Richardson** has been appointed a director of Head Wrightson & Co. Ltd.

★ Among 36 members of the staff of Humphreys & Glasgow Ltd. who received gold watches to mark 25 years' service or longer were both joint managing directors, **Mr. G. Helps** and **Mr. G. G. Farthing,** who have been with the company for 37 and 35 years respectively.

★ The Power-Gas Corp., of Stockton-on-Tees, has announced the appointment of **Maj. W. R. Brown,** D.S.O., as chairman and managing director in succession to the late **Dr. N. E. Rambush** (see CHEMICAL & PROCESS ENGINEERING, June, page 224). Maj. Brown is well known in the iron and steel industry, at home and abroad, for his work in connection with the design and construction of modern blast furnaces. He has played a prominent part in building new plants that are required for the large expansion which has been taking place in the iron-making industry for the last 20 years or so.

★ **Mr. A. D. Buckland-Nicks** has been appointed industrial field sales controller of the Shell Chemical Co. Ltd., a post in which he will supervise the operation of all the sales divisions and will act, when necessary, as deputy for **Mr. P. J. March,** the new marketing manager (industrial). **Mr. R. A. Atkinson,** who joined the company in 1945 as a technical representative and became northern regional manager in 1955, has taken up a senior position with the chemical industry administration of the company.



Maj. W. R. Brown

★ **Mr. D. W. Payn** has been appointed general manager and secretary to the Lead Development Association.

★ At the tenth annual general meeting of the Fertiliser Society **Dr. B. Raistrick** was elected president and **Dr. E. M. Reid** vice-president.

★ **Mr. W. M. Thompson** has been appointed a director of Monsanto Chemicals Ltd. Mr. Thompson, who will continue in his office as sales director of the company, had previously been an alternate director since July 1956.

★ **Mr. D. E. Roberts** has been appointed a division manager in the buying department of Thomas Hedley & Co. Ltd. He will be responsible primarily for the buying of chemicals, chemical plant and equipment.

★ **Mr. H. A. Arnold** has been appointed president of the newly formed Olin Mathieson International Corp. He was formerly vice-president of Olin Mathieson in charge of its South American operations and also president and managing director of E. R. Squibb & Sons Argentina S.A. In his new post he will be responsible for all of Olin Mathieson's overseas activities.

★ **Mr. J. R. V. Dolphin,** C.B.E., who has been chief engineer to the Weapons Group of the United Kingdom Atomic Energy Authority since 1951, has been appointed chief engineer to the Authority's Research Group. He will take up his new duties at Harwell on August 1.

★ **Sir Graham Cunningham,** chairman and managing director of the Triplex group of companies, which includes Q.V.F. Ltd., has been elected a Visitor for the Royal Institution of Great Britain.

★ **Mr. R. Kris** has been appointed general manager of Aeroplastics Ltd., a subsidiary of the Fairey Aviation Co. Ltd. He was formerly managing director of Welwyn Plastics Ltd. and general manager of East Anglia Plastics Ltd.

★ British Oxygen Chemicals Ltd. have announced the appointment of **Mr. A. J. Oxley** as production manager at their works at Chester-le-Street.

Welding and Fabrication of High-nickel Alloys

(*Concluded from page* 288)

Leading on from the question of the inadequacy of lined vessels, Mr. Phillips claimed that experience has shown conclusively that vessels made from thicker *Hastelloy* plate can be produced at least as cheaply as those made by lining, using a thinner gauge of material.

The construction of such vessels has presented no particular difficulties —the general procedure being to anneal fully the separately machined and formed parts of the vessel prior to final assembly welding. In cases where the vessel has to be constructed to a high degree of accuracy, component parts are annealed after 90% of the deformation has been carried out—the amount of cold working experienced in the remaining 10% of deformation does not lead to any serious stress-corrosion trouble or weld cracking. In only very few cases have the finally assembled vessels been heat treated, principally because of the difficulty in exercising a sufficient degree of temperature control over such a large space and also due to the extreme danger of buckling and deformation in large structures due to the low mechanical strength of a material near its melting point.

WHAT'S NEWS about

★ Plant
★ Equipment
★ Materials
★ Processes

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in the top postcard attached, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

Portable turbo-reactor

With a two- or three-speed drive, a portable turbo-reactor comprises a rotor revolving within a specially-designed stator with pins. It has the effect of creating an intense and controlled circulation, compressing the liquid streams, dividing into fine jets, and ejecting with great force.

A complete unit is composed of a vertical, flange-mounted motor, either semi-protected, totally enclosed or flameproof; the rotor and stator; a shaft; and an aluminium flange bolted to the motor carrying the tube.

The unit can be mounted on channels or to the side of a vessel or against a wall and it has applications in a wide range of industries, including chemicals, plastics, paints and varnishes, food and textiles. **CPE 643**

Coolant separator

Designed to remove impurities, sludge etc. from suds and other coolants, a new separator unit can also be adapted for extracting ferrous impurities from other liquids, including lubricating oils, chemicals, potters' slip and paints.

The contaminated liquid is fed through a restricted area between the separator housing and the stainless steel cover of a magnetic drum. The magnetic drum, which is energised by powerful magnets fitted around its periphery, rotates in the opposite direction to the flow of liquid.

Ferrous particles in the liquid are thus attracted to the cover of the drum, and discharged on to a chute at the front of the separator after passing under a roller which squeezes out the liquid remaining in the sludge. The cleaned liquid flows from side outlets located near the front of the separator, and is then ready to be re-circulated.

These equipments are available in a wide range of capacities from 10 gal./min.—in increments of 10—to approximately 40 gal./min. The only electric supply needed is that for the motor which drives the magnetic drum.

Magnetics adhering to the drum face form a mechanical filter which also collects non-magnetic abrasive particles. For ease of cleaning, plugs are suitably located on the machine where sludge may collect.

Separator for extracting ferrous particles from liquids.

The use of this type of equipment, it is claimed, has been proved to produce increased tool and wheel life, less coolant loss and consequent increase in life; also a higher standard of finish is obtained. **CPE 644**

Synthetic rubber tank lining

A ready-to-apply synthetic rubber lining for tanks and chemical equipment has been developed in the U.S. Because the sheets are vulcanised during manufacture, installation is greatly simplified, since air-drying will cure the cement without heat.

Chemical resistance, economy, and ease of application are important advantages of the new material. Still another is the fact that equipment and tanks can be lined or re-lined in place, without expensive equipment.

Use tests have shown that the new *Fairprene* T-5594 ready-cured synthetic rubber lining material has good chemical resistance to inorganics such as hydrochloric and sulphuric acids, ferric and aluminium chlorides, and to organics such as benzoic, tannic, and tartaric acids. It is not recommended for protection against petroleum products.

Although designed primarily as a lining for tanks, it has been used successfully in other applications. For example, a pipe and elbow lined with the new material has carried 12% sulphuric acid for more than a year,

C.P.E.'S MONTHLY REPORT AND READER SERVICE

while laboratory hoods, chemical drums, and even a pipe-line carrying pulverised coal have been protected with it. **CPE 645**

Flow integrator

The new *Transet* receiving flow integrator simply combines an integrator with a low-pressure receiving bellows (3 to 15 p.s.i.) and fitted into a compact unit adaptable to graphic panel design. Mounted on the graphic panel, the integrator totals the flow of liquids and gases at remote distances and is available in square root or linear forms.

The integrator is a precision-built device consisting of a synchronous speed motor, an oil-proof, positive-acting clutch and a counter mechanism. A low-pressure bellows actuates this mechanism after receiving the impulse from the transmitter mounted on the process. For any position-impulse received from the transmitter, a proportional position of the sensing arm of the integrator is effected. The sensing cam contour is either square root or linear form. The sensing arm limits the vertical travel of this cam and provides a means for flow totalisation. **CPE 646**

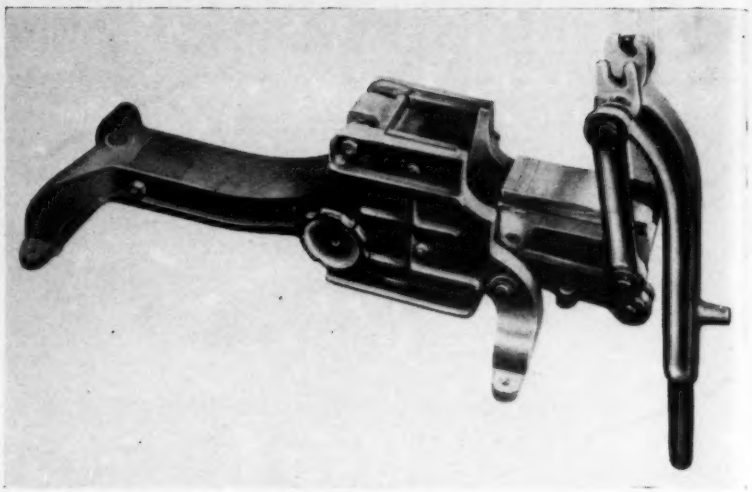
Controlling temperatures

A high degree of accuracy is claimed for a non-electronic proportioning temperature indicator/controller which has recently been introduced. The proportioning band may be readily adjusted to suit the user's heat supply/demand conditions. Various ranges are available, from sub-zero Centigrade to over 250°C.

The well-tried liquid-filled bulb, capillary and bellows, is employed and the novel proportioning system, consisting of a thermo-electric unit, allows the temperature to 'inch' up (or down) to the selected control point. Temperature overshoot and undershoot, it is claimed, is entirely eliminated.

The thermo-electric proportioning unit immediately responds to changes in heat supply/demand ratio and the necessary degree of compensation is automatically applied.

The instrument has proved particularly successful in stabilising plastics processing temperatures. **CPE 647**



Jaw crusher.

Hand-operated jaw crusher

Specifically designed to deal with small, occasional samples where the installation of a power unit is not warranted or where sampling may be carried out far from suitable sources of power, a hand-operated jaw crusher, constructed of aluminium alloy wherever possible, has been produced as a lightweight unit easily carried by one man and capable of reducing material from 1½ in. cube down to ⅛ in. at the rate of 40 to 45 lb./hr.

The unit consists of two manganese steel jaws, one of which is fixed, the other being hinged at its base and coupled at the top to a handle or lever of malleable iron. For cleaning, this lever is arranged to fold back over the movable jaw, thus giving clear access. Jaw setting is controlled by a cast-iron hand wheel and spacer bolts and locking cam are of mild steel.

Hitherto in field work reduction of samples has called for laborious hand spalling, with consequent risk of loss of sample by the scattering of 'chats,' a method also calling for close supervision. With the new hand-operated jaw crusher risk of loss by flying particles is eliminated, labour requirements are considerably reduced and a greater production per man is possible without supervision.

In laboratory work the new crusher meets the demand for a unit which may be installed to deal with occasional samples without tying up the greater expenditure incurred with the installation of a powered unit. **CPE 648**

Loading bulk materials

Recently added to a range of loading shovels, a new unit can get 'almost anywhere,' as it is only 4 ft. 6 in. wide, with a wheel base of 4 ft. 9 in. It is highly manoeuvrable, and whilst it can be operated under a ceiling of as little as 6 ft. 3 in., the machine has the advantage of an exceptionally good forward reach, together with a discharge height that is more than adequate to load tippers and other trucks of usual type.

A range of scoops is available to accommodate the handling of a wide variety of materials and high production figures are possible even under extremely cramped working conditions, especially when handling such materials as sugar, salt, phosphate and other fertiliser, china clay, foundry sand, swarf, coal and coke, oxide, glass, pitch and bones etc.

Operator comfort and safety has received special attention, and an offset seating arrangement is provided which, together with the interesting single boom arrangement successfully avoids the necessity of seating the driver between moving parts. This adds to the operator's confidence when handling this machine in confined working spaces, or when, as is usually the case, especially fast work is called for. **CPE 649**

Centrifuges

New centrifuges for both laboratory and larger-scale work include the following:

Laboratory basket centrifuge. This model is useful for the dehydration, clarification and recovery of solids from suspensions and can be used for continuous operation up to a cake capacity of about 300 cc. (ml.). Features include the motor base, stainless-steel draining chamber and 5-in.-diam. basket which is detachable from the tapered motor shaft. Stepless speed control is another important feature, while the motor bearings are grease-packed so that no lubrication is necessary. Baskets are held by a single knurled nut and are therefore easily removable.

A larger model, embodying similar principles to the laboratory machine just described, gives a cake capacity of 3,000 ml. The flow rate of water with an unperforated basket at 3,000 r.p.m. is 150 gal./hr. A slightly lower flow rate is obtained at the maximum speed of 4,000 r.p.m.

Oil testing centrifuges. These have been developed specially to cover the routine oil and petroleum tests of the I.P. and A.S.T.M. and there are two models, the *Medium* and the *Magnum*. The latter, which has a larger centrifuging compartment, can be used for all tests. **CPE 650**

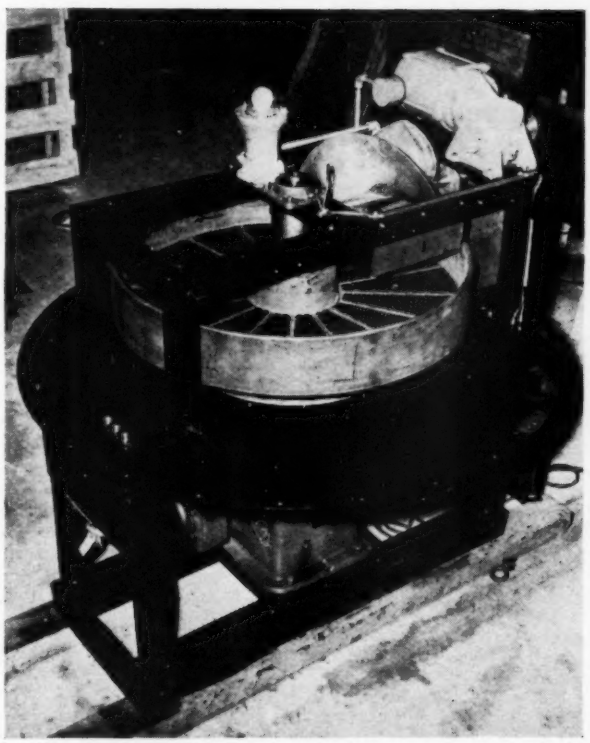
Horizontal rotary filter

Horizontal rotary vacuum filters which have applications in the chemical, food and colliery industries are now being manufactured in Britain under licence from a U.S. firm. One of the main features of a table filter is that it is ideal for easy filtering materials where ample washing is required.

The filters are manufactured in a standard range of sizes from 3 ft. to 12 ft. diam., but special sizes can be made to specification. In addition, modifications can be made to make the filter suitable for any particular application.

Those sizes from 3 to 8 ft. are fitted with a centrally mounted, variable-speed drive which is installed in the base of the frame. This is particularly useful in that it eliminates the necessity and cost of separate foundations, and the filter can be moved easily if desired. The larger sizes use a conventional spur gear with roller chain drive which, however, has a ball-type main bearing with a replaceable hardened race.

This filter has the advantage of high dewatering capacity, large cake capacity and good cake washing which makes it particularly suitable for the continuous filtration of free-settling or free-filtering materials such as coarse crystalline substances and fibrous pulps. Among the numerous operating advantages is the fact that all the filtering and washing operations are visible and, therefore, easily controlled. There is a high hourly output per sq.ft. surface, and cake thicknesses up to 4 in., or even more in special cases, can be readily handled. **CPE 651**



Rotary vacuum filter.

Reinforcing fabric for pipelines

Rotproof fabric designed for use as a reinforcing membrane for the coal tar and asphalt compounds used in waterproofing and anti-corrosion applications is now being produced.

Known as *Tygascrim* it is an open-weave fabric weighing only 2.2 oz./sq.yd., with high tensile and bursting strengths. It is woven from glass yarns and coated to ensure maximum compatibility with coating compounds. Its tensile strength is 75 lb./in. in both warp and weft directions and its bursting strength 140 p.s.i. When used as a reinforcing membrane it ensures a considerably longer effective life for protective coatings by preventing the formation of 'holidays' during application and resisting cracking due to building movement, temperature variation or, when used underground, soil stresses. Its high tensile strength makes it highly suitable for machine application to pipelines.

The principal advantage claimed for the new fabric is that, being woven from inorganic yarns, it does not rot or decay or carry moisture into the waterproofing compound. This last feature is due to the non-wicking properties of the glass filaments and has a further advantage in that the fabric does not conduct vaporisable oils to the surface, thus preventing drying out of the compound. A further valuable characteristic is that the base fabric is capable of withstanding temperatures of up to 1,000°F.

so that coating compounds can be applied at normal temperatures without risk of degradation.

One of the principal fields of application for this fabric is on underground pipes, joints and fittings and on the interiors of oil storage tanks. Application techniques vary, but the normal procedure is to apply a suitable primer to provide a bond between the metal surface and the coating compound which is then sprayed on. **CPE 652**

Soldering stainless steel

Known as *Epatam* 3311, a new solder paint effects speedy hot tinning of stainless steel and, possessing high degreasing and penetration properties, it also effectively tins through iron welding scales, rust and grease, depositing a bright tinning. **CPE 653**

Self-adhesive tape

Strong high-tack self-adhesive tape capable of strapping and banding really heavy items is made on a waterproof vinyl base to which is fused a continuous layer of reinforced rayon yarn threads, which are in turn impregnated with a strong adhesive which will give a firm grip over a wide range of surfaces.

Breaking strain of the product is claimed to be not less than 180 lb./in. width. At the same time it is pliable and flexible, so that it follows the contour of the uneven surface with the greatest of ease. In application the reinforcing yarns will tend to bond to the surface of the carton, forming an integral part of the pack, whilst the vinyl covering provides complete protection against damp. **CPE 654**

Drum heaters

Drum heaters produced in two sizes to fit any standard 15- or 45-gal. drum are available to ensure that the entire contents can be removed from drums carrying materials of a viscous or solidified nature, such as paints, resins, oils, waxes, bitumens or tars.

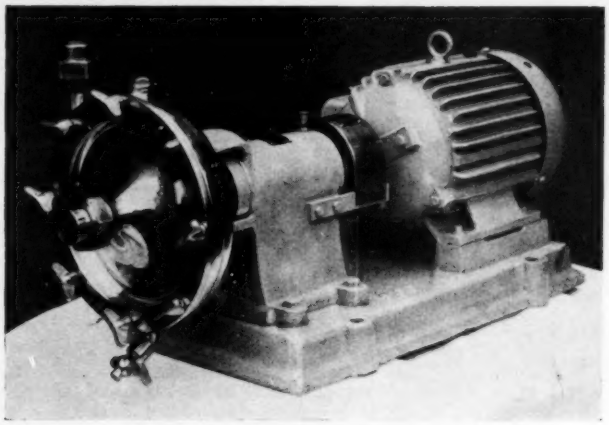
Usage is simple; the drum is enclosed in the heater, the predetermined and thermostatically-controlled heat is applied, and after the necessary period of time has elapsed (dependent on the material and the thermostat setting) the contents of the drum can be easily and absolutely removed.

A further elimination of time and expense results from the fact that preparation of the drum for re-use is speeded up. Heat applied by the drum heater effectively allows content remnants (now liquified) to be removed simply. A further heating dries the drum. **CPE 655**

Centrifugal pumping sets

Stainless-steel centrifugal pumping sets are produced by one company which, rather than manufacture a standard range of pumps, in which capacities may be increased or decreased according to the speed at which the unit is run, tends to design each unit for a constant speed of 1,440 r.p.m. and to give the actual capacity the client requires.

Advantages claimed are that the liquids are not agitated any more than is necessary, and the working life of the unit is prolonged. The pumps have a high standard of finish and are easily dismantled. **CPE 656**



Pumping unit.

New furnaces provide temperatures up to 3,000°C.

Graphite resistor furnaces capable of providing temperatures up to 3,000°C. have been developed. They meet the demand created by development work on atomic energy, guided weapons and supersonic aircraft, for high temperatures required in the heat treatment of the new metals (titanium, tantalum and zirconium), for sintering, and for brazing components which will operate at elevated temperatures.

One of the first of these new high-temperature furnaces has been installed in a powder metallurgy research laboratory. Designed to give temperatures up to about 2,000°C. and to maintain a good vacuum for the protection of a charge from oxidation, it is to be used for sintering materials for use at high temperatures.

The body of the furnace is a water-cooled, vertical, cylindrical, steel tank with a hinged, domed lid. A vacuum-tight seal is formed between flanges on the lid and the furnace body. The charge is heated by radiation from a triangular-shaped assembly of graphite bars which surrounds the charge space. These graphite bars operate at a low voltage supplied by a three-phase transformer. A voltage regulator enables the secondary voltage of this transformer to be steplessly varied to give control over the heating rate.

Radiation screens consisting of molybdenum sheets, so arranged as to enclose the heating chamber, provide the thermal insulation. With the furnace lid raised the top radiation screen can be lifted to give access to the chamber. The charge is supported on a graphite tripod. **CPE 657**

Size reduction equipment

Designed to produce uniform particle size reduction within the small or medium range, a vertical disintegrator is claimed to be capable of handling wet or moist materials with less fear of clogging than is usual. In many cases economies are quite considerable, as drying operations can be completely eliminated.

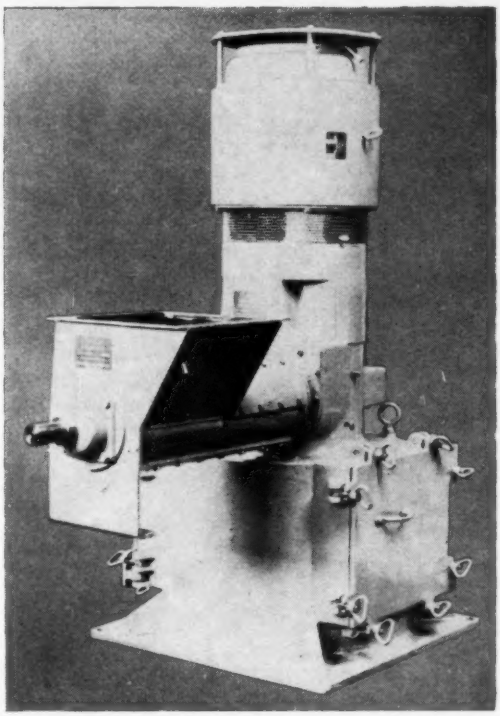
Further advantages are that less floor-space is required, there is a complete absence of vibration, and the continuous gravity feed gives high output with a small power unit. Disintegrators can also be used for crushing, grinding, pulverising, pulping, shredding, triturating and de-fibrising.

An alloy or stainless-steel rotor is surrounded by a perforated screen, the size of perforations depending on the size of product required. Material is introduced to the machine at the top of the shaft above the rotor, which is revolving at high speed. Centrifugal force throws it out against the screen. Hammers rotating in the horizontal plane do some shattering of the material, but the greater part of the work is done by attrition.

Where it is desired to separate the material into a primary and secondary product or remove a 'tramp' or disintegration-resistant component, this can be done continuously and automatically by the special differential discharge.

The primary product passes through the screen and out through the main discharge. The secondary product remains inside the screen, and is passed out through the secondary discharge. An easy-to-grind material where no 'tramp' component exists can be ground completely through the screen by closing the secondary discharge.

CPE 658



Vertical disintegrator fitted with integral pre-breaker feeder.

Water sterilisation

Filters employing kieselguhr as their filtering medium had to have the candles removed periodically and sterilised by boiling to avoid the tendency of bacteria to develop in the sediment collected on their exterior. Experiments recently carried out with finely divided silver showed that if this could be effectively introduced the bactericidal properties of the silver ions would produce a more lasting sterilising action.

An efficient process was finally devised to ensure thorough and uniform penetration of the silver into the kieselguhr candles and subsequent tests lasting for two years revealed that water which was artificially contaminated to a degree such as would never be encountered in any supply provided for domestic purposes was made safe for drinking by a single passage through the candle. Furthermore, the water so treated could be stored for considerable periods without bacteriological deterioration.

Since the development of this type of candle (to which the name *Sterasyl* was given) every test made has shown complete absence of *bacillus Coli* in the filtered water and the life of the candles has been recorded as being upwards of two years. Spore bacilli and algal growth which are resistant to normal sterilising agents are also destroyed by the *Sterasyl* process.

The only maintenance required is occasional cleaning with a soft brush in clean water when the rate of filtration shows signs of slowing down. No soap or detergent is necessary.

CPE 659

'Pullout' recorder/controller

The new addition to the *Consotrol* range of instruments is the M/54 recorder/controller with an important extra facility. The recorder, complete with the controller (when mounted at the rear of the recorder), can be removed completely from the panel whilst the transfer switch is in the 'seal' position. The entire unit slides into a sheet-steel housing which is secured to the panel and to which are attached all the external connections. These, electric and pneumatic, are of the plug-in type and when the unit is withdrawn from the panel a series of air check valves automatically close to prevent loss of pressure in the impulse lines.

When the M/54 is used as a recorder/controller, an M/58 *Consotrol* controller may be integrally mounted with the recorder and the ease with which the instrument can be withdrawn from the panel simplifies the adjustment procedure.

The pull-out feature permits a complete instrument to be replaced without

disturbing the process. Since the control system can be transferred from automatic to manual control, the M/54/58 can be removed from the panel and replaced by a service spare unit on which the setting index and controller settings have been adjusted to agree with the values already obtained. Bumpless transfer using the M/54 auto-seal-manual transfer switch ensures that the system is brought back into completely automatic operation a few minutes after the changeover operation is commenced. It follows that routine maintenance and inspection can be carried out with the minimum of interference to the process operation and an emergency condition can be met with little loss of performance. **CPE 660**

Polythene containers

Stacking bins, suitable for handling corrosive chemicals and fluids and for the processing and storage of food are being produced in polythene. A 5-gal. stacking bin has a specially designed lid which allows a completely lidded container to be stacked on top of it. A larger stacking bin with a capacity of 10 gal. is produced in rigid high-density polythene. The range of products also includes a 2½-gal. bucket in the same material.

The softening point of rigid polythene is 116°C. with a melting point of 130°C. and a low temperature brittle point of –70°C. An additional advantage is that these products can be sterilised in boiling water without any harm. **CPE 661**

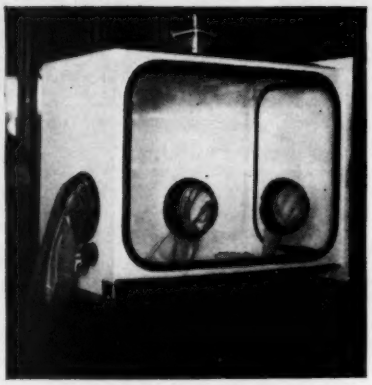
Corrosion-resistant pumps

The *Gush* range of pumps for the chemical and process industries is claimed to be good for more than 100 corrosive duties at temperatures up to 110°C. Rubber-lined pumps are made in capacities up to 30,000 gal., at heads up to 200 ft.

Small crevices have been reduced to a minimum in the construction of these pumps and the gland drip trough is easily cleaned and washed out. As the bearings are sealed in the cartridge, harmful vapours or liquids cannot attack them.

The gland is easily accessible for renewal of the gland packing, which is extracted ' whole,' it being unnecessary to resort to the usual laborious method of picking the old packing out in small pieces. The gland housing is not of the split type, but is detachable.

Where severe corrosive or abrasive conditions warrant a material of universal application, *Lumasil* 109 shafts may be fitted. It is suitable for most corrosives at temperatures up to 180°C. and is claimed to show practically no wear at the gland even when abrasive particles (such as sand or carborundum) are embedded in the gland packing. **CPE 663**



REMOTE HANDLING

Development of processes involving materials with a high alpha activity such as plutonium can only be carried out safely in a totally enclosed cabinet or cubicle of the glove-box type. Facilities suitable for handling these materials on a small pilot plant scale have been developed in the chemical research laboratories of A.E.R.E. and this glove box was manufactured to Harwell specifications. The material is inserted or removed through a posting port, or alternatively, through a bung which is itself removable internally. Air filtration and ejection equipment is included on all models. **CPE 662**

Spray gun

A spray gun has been designed for spraying materials of all types which are unstable by nature, which will not tolerate agitation and violent changes of direction of flow and which cannot be readily removed from the spraying equipment by normal cleaning.

Its fluid passage is a straight tube, end to end, and is normally made of stainless steel, but this can be changed for any required material which can be machined, so that the gun can easily be adapted for use with highly corrosive, abrasive and other difficult fluids.

It will handle all materials requiring an unobstructed fluid passage and is expected to have an immediate application where unstable latex emulsions have to be sprayed, as well as in the ceramic industry, where unstable suspensions are commonly found. **CPE 664**

New telephone system for refinery

One of the latest private automatic branch exchange telephone systems has been ordered for a refinery at Visakhapatnam on the east coast of India which is due to begin operating later this year. Spread over some 515 acres, the refinery requires speedy communication between all sections.

Known as the Type 211, the new automatic exchange has been specially designed to meet the needs of overseas users requiring 100 telephone extensions or more. The equipment is fully tropicalised, and provides speedy internal communication as well as access to public exchanges—all from the same telephone.

The refinery exchange will have an ultimate capacity of 300 telephones, with 20 or more exchange lines, and unit type construction makes the equipment easily extensible.

A feature of the equipment is the cordless switchboard which includes devices to ensure that if the switchboard should be left unattended at night, all incoming calls can be answered from other points of the plant. **CPE 665**

Strip chart recorder

Operating in conjunction with an electrical transmitter, a strip chart recorder provides a permanent record of variables such as flow, level, pressure, machine operations, smoke density, etc.

Provision is made for up to four independent transmitter stations to operate with one recorder. The recorder is designed primarily for operation with a *Telecoil* transmitter of the same make, but may also be used with any electrical transmitter which provides the necessary signal output.

An electrical signal which is proportional to the variable to be recorded is fed from the transmitter to a moving coil galvanometer housed in the recorder. A chopper bar mechanism operating periodically prints a record of the variable on to a moving chart.

The independent transmitter stations are accommodated by means of

a switching arrangement which provides for the signal from each station to be fed to the galvanometer and recorded, in turn. Each record is identified by means of a colour code.

CPE 666

Motorised pestle and mortar

A soil grinder, useful in agricultural research and other applications, has been developed and a prototype machine is being exhibited in London. The unit consists of motorised mortar and pestle with a capacity for grinding samples of soil and passing them through a 2-mm. screen in the base of the mortar.

The mortar is strongly constructed from cast iron with a detachable steel or rubberised-steel base, making for easy removal of sample residue. Lowering of the base is accomplished through a cam mechanism, operated by lever action. The steel pestle, available with a covering of rubber, *Tufnol* etc., is rigidly mounted on self-lubricating bearings. Weights are supplied for loading the pestle to enable grinding of any soil sample.

CPE 667

Adsorber filtration equipment

Designed especially for certain industrial processes which demand filtration efficiency of virtually 100%, a three-stage filtration system employs a pre-filter followed by a carbon adsorber, which is in turn followed by a final filter of a similar type to the pre-filtration element.

This carbon adsorber and filter system removes from air and gases the organic liquids, the vapours, flavours and odours which may otherwise jeopardise or impair a process or product.

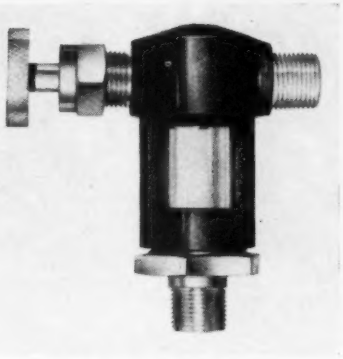
The pre-filter removes gross liquid impurities, wild yeasts and airborne bacteria, the final filter prevents ingress of carbon particles from the adsorber unit into the gas stream.

The three-stage carbon adsorber filter system is of particular interest because it is assembled from standard units and thus provides maximum flexibility, utility and availability over a wide range of flows and working pressures up to 7,000 p.s.i.g. If desired a chemical engineer may build up the system in stages starting with a single filter in the supply line.

CPE 668

Sight feed indicator

A new sight feed indicator not only provides flexibility of liquid flow but permits control of the amount of oil or other liquid being used, and is stated to be applicable in paper-mill oiling systems, steam and gas engines, sugar-mill machinery and a variety of other equipment.



Sight feed indicator.

The device being of the double-window type, with drilled outlet nozzle, the size of the liquid stream can be observed from either side. Extremely fine control of the amount discharged is made possible by the port-hole type of regulator and the very fine thread of the needle valve.

It is designed for rigid pipe or flexible hose connection on inlet and with a range of outlet adaptors to suit individual requirements. The indicator is vented to prevent fogging.

CPE 669

Getting rid of noxious fumes

Fumes, vapours, gases and odours of an organic nature produced in many industrial processes ranging from asphalt blowing to paint manufacture, and from organic chemical plant to paper manufacturing can be treated by a catalytic combustion process, introduced from the U.S.A., which converts them to odour-free gases.

Catalytic combustion is the low-temperature, flameless oxidation of combustible fumes and is applied to greatest advantage where the available energy is substantially below the lower limit of flammability.

Catalytic combustion has no minimum fuel air limits, and the oxidation temperature is no more than 500°F. approximately. The temperature rise of the fumes passing through the catalyst element is proportional to the concentration of combustible material which they contain. The heat liberated per unit quantity of hydrocarbons is the same as with flame combustion. With catalytic combustion there is no flame, but the catalyst may glow at high fume concentration.

The catalyst element is a frame on which a narrow heat- and corrosion-resistant nickel alloy ribbon enclosed between heat-resistant alloy container screens is mounted; a coating of certain metals of the platinum group is bonded to all surfaces of the nickel alloy ribbon to form the catalyst. The element is of sturdy construction, and in general appearance resembles a metallic air filter mat. Elements of standard dimensions are used and can be grouped to handle any desired volume of fumes. The pressure drop across a complete assembly is low, being of the order of $\frac{1}{4}$ to $\frac{3}{8}$ in. w.g. Dust particles normally present in the atmosphere have no clogging effects on the catalyst. If large amounts of sand, fly ash and similar substances are present in the fumes, they must be removed prior to treatment in the plant.

CPE 670

Outdoor paint

Silicones are an ingredient of a synthetic-rubber-based paint for concrete, brickwork, stucco, plaster and all other outdoor masonry surfaces.

CPE 671

Pads prevent vibration

Anti-vibration pads for machine installations are manufactured from oil-resistant rubber of a special resilient non-ageing quality. When the weight of the machine presses down on them, the ribs of the pad grip the floor so firmly, that in most instances it is no longer necessary to bolt down machines to the floor. The ribs also prevent the machines from rocking or wandering.

Erecting and shifting of machinery is thus greatly simplified, apart from the fact that the absence of bolts will also eliminate the danger of vibrations being transmitted through the floor to other machines or instruments in the vicinity. The pads can support and isolate a load of 4 tons/sq.ft.

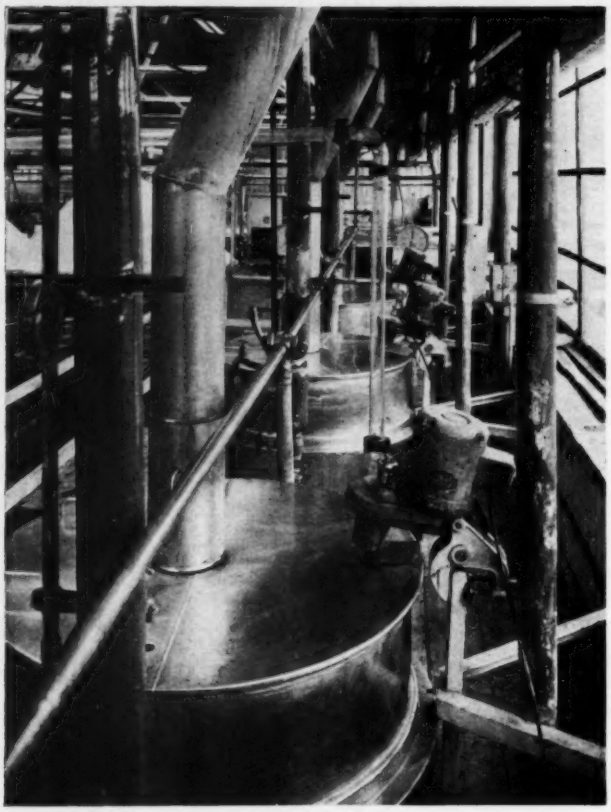
CPE 672

Providing purified water

Purified water at tap speed far exceeding pharmacopoeia requirements is provided by the latest addition to a range of laboratory equipment. Cost, it is claimed, is much lower than that of distilled water; no supervision or maintenance are required and a cartridge exchange service avoids regeneration *in situ*.

The deioniser has two applications: the provision of washing water for slides and for any work where single distilled water is normally used in the laboratory. A further important function is the provision of distilled water for batteries. Many factories now use fork lift trucks. One of the problems in the maintenance is the storage of distilled water and this equipment provides an ideal medium for its provision and avoids bulk storage altogether.

Another model, with conductivity metre, is intended for the research laboratory. Effluent purity is monitored and is well above 4 million ohms/cm. (conductivity water). The effluent may be piped to any number of benches. **CPE 673**



AGITATORS

A series of side-entry agitators are here seen in use with stainless-steel vessels in a food factory. For smaller-scale work where vessels of over 100-*gal. capacity are concerned, a portable model is available with several useful features, the main one being that the agitator shaft is adjustable for length and therefore an individual unit can be applied to a large variety of containers.* **CPE 674**

WORM GEAR UNIT

A British product which was recently selected in a competition in the U.S. as one of the outstanding contributions of 1957 towards the technological advancement of the mining industry is the *Radicon* worm gear unit. Some of the smaller units of this type were used in the production of penicillin in its early development; in the commercial production in Canada of the Salk polio vaccine; in artificial breathing apparatus of the 'iron lung' type; and in the initial production of all uranium emanating from South Africa, which supplies about 60% of world output.

In mining, their main application is in driving conveyors, wagon tipplers, and washing, crushing and screening plant. **CPE 675**

Rust-preventive coating

A spirit-based heavy bituminous substance, *Ibetol* (*X*), 'knits' itself to new steel, or derusted and cleaned steel, and provides a coating resistant to moisture, acid fumes, salt water, salt-laden atmosphere and a large number of acids.

The material is thixotropic—undisturbed in the drum it appears too heavy for application, but on stirring becomes a smooth heavy fluid, easy to apply. Almost at once it begins to revert to its original stiffness, preventing flow, sag or curtaining.

According to the makers, the coating is not affected by conditions of widely varying temperatures or high humidity. Applied by brushing or spraying, it can be used on damp or dry surfaces, as would be the case for concretes. **CPE 676**

Printed polystyrene tubes

Printing on white polystyrene tubes, now being offered, is confined to line printing in two colours, but the effect is both attractive and striking. An extremely high standard of decoration can be obtained, with no loss of adhesion of the print to the surface of the tube.

White tubes (but not transparent ones) can be printed in up to two colours, with a choice of orange, crimson, scarlet, black, green, turquoise, Chinese blue, deep blue and mid-red shade blue.

The tubes are tough and light and are rigid enough to protect the contents even against heavy pressure. A polythene stopper gives them an effective seal, but is easy to remove and to replace. **CPE 677**

Chemical and Engineering Research in Australia

Investigations over a wide field of pure and applied science are described in the eighth annual report of the Australian Commonwealth Scientific and Industrial Research Organisation for the year 1955-56. Here we summarise some sections of the report which are of especial interest to chemical engineers.

CHEMICAL ENGINEERING

Utilisation of brown coal

Particular attention continues to be given to the investigation of the kinetics of the chemical reactions which occur when brown coal is gasified in a pressure generator. One of the important features of the pressure gasification process is the ability to produce a fuel gas rich in methane. A study is being made of the reactions which occur when brown coal and brown-coal char are contacted with hydrogen-carbon monoxide mixtures under controlled conditions of temperature and pressure, to enable the important methane-forming reactions to be identified and their kinetic features determined. The experimental reactor is of the continuously operated fluidised-bed type, designed to operate at a wide range of temperatures and pressures up to 50 atm. The fluidised-bed reaction system was chosen in order to control closely the reaction conditions and thus to facilitate the interpretation of experimental results.

Experimental runs have shown that the hydrogenation of the carbon content of reactive brown-coal chars occurs rapidly at temperatures of about 750°C. and pressures of 20 to 30 atm. The thermally unstable components of brown coal are also readily hydrogenated under these conditions, but much of the reacting hydrogen combines with the oxygen content of the coal to produce water. Very little methane appears to be formed by reaction between hydrogen and carbon monoxide.

Although many previous workers have investigated the kinetic features of the steam-carbon reaction with steam partial pressures of 1 atm. or less, very little work has been done at higher pressures, and predictions of the possible rate of the reaction under pressure gasification conditions vary widely. In the present investigation, precise studies at steam partial pressures up to 40 atm. have yielded sufficient results to indicate that the reaction is described by a rate equation exhibiting the fractional order with respect to steam and the retarding effect of hydrogen which are characteristic of the reaction at low pressure.

Work has commenced on the study of the gasification behaviour of a series of special carbons, the chemical structures of which have been established by officers of the physical chemistry section. Initially, the reaction of these carbons with oxygen and carbon dioxide at low temperatures will be investigated. It is hoped that this work will help to elucidate the nature and function of the surface complexes which play an important part in the mechanisms of the oxidation reactions by which carbon is gasified.

Studies of the fine-pore structure of brown-coal chars, using the high-pressure mercury penetration apparatus, have been continued.

Fluidisation of solids

Research on fluidised-solids systems includes basic studies of the characteristics of fluidised beds, the accumulation of data for the design of large fluidised-bed reactors, and a pilot-plant investigation of the fluidised-bed roasting of copper concentrates.

The present emphasis in the basic research programme on the properties of fluidised-solids systems is on the study of gas bubbles in fluidised beds. In this work the object is to determine how bubbles form and grow, and what effect they have on the degree of solids mixing, and the efficiency of gas-solids contacting.

In connection with the development of the multi-cone air distributor for the pilot-plant roaster referred to below, a considerable number of fluidisation tests in large-scale models have been performed. These tests permitted the determination of the optimum size and shape of cones to ensure satisfactory fluidisation of particles of varying size range, and provided information on the factors influencing the uniformity of air distribution in units of large cross-sectional area. This information has been incorporated in a design for a commercial-size fluidised-bed roaster employing the multi-cone principle.

Roasting of copper concentrates

This pilot-plant investigation comprises the first part of a co-operative project with Mt. Morgan Ltd. and the Mt. Lyell Mining & Railway Co. Ltd., the object of which is to evaluate a hydrometallurgical process for the recovery of copper and precious metals from sulphide concentrates. The process consists of the controlled roasting of the concentrates to convert the copper into a form soluble in dilute sulphuric acid, the leaching of the calcines, and the electrodeposition of the copper from the leach solutions. The precious metals which remain in the residues are recovered by cyanidation.

During the year a large number of runs of the 3 ft. 6 in.-diam. pilot-plant roaster were performed to investigate the influence of the roasting temperature, the proportion of excess air, the grade of concentrate, the feed rate, and various aspects of roaster design on the calcine composition and properties. It has been demonstrated that calcines with very favourable leaching properties, *i.e.* high copper extraction, low iron extraction, and high acid consumption, can be produced by suitable choice of the operating conditions. Runs aimed at the production of calcines for reverberatory furnace smelting have also been most successful.

Operating difficulties caused by the agglomeration of calcine particles in the fluidised bed have been completely overcome by the development of a new design of roaster bottom, *i.e.* the multi-cone air distributor. In this design the number of tuyeres through which the fluidising air is introduced is much reduced, and each is placed at the bottom of an inverted narrow-angle hollow cone

moulded in the refractory concrete hearth of the roaster. The upper ends of the cones are developed to fit together into a hexagonal pattern with a minimum of flat surface between them. Thus the air velocity in the lower portion of the bed increases greatly towards the air entry point, and this prevents the defluidisation of large agglomerated particles which would otherwise segregate and sinter together into troublesome accretions. Experimental runs have shown that a roaster constructed in this way is, in addition, very much more flexible with regard to throughput, and enables better control to be obtained over calcine composition. A patent covering this development has been sought.

The major objects of the current experimental programme have now been achieved. A small experimental roaster (12-in. diam.) has been constructed to enable a more detailed study to be made of some aspects of the chemistry of the roasting process, and to provide for roasting tests on special types of concentrates which are available only in small quantities.

The two other major copper producers in Australia, Mt. Isa Mines Ltd. and Peko Mines N.L. Ltd., have now become associated with this project.

ORGANIC CHEMISTRY

The research programme is principally concerned with the following projects: the investigation of the chemistry of wool wax and suint with a view to their wider industrial utilisation; the utilisation of sugar-cane wax; the examination of Australian plants for pharmaceutically valuable alkaloids or substances toxic to livestock; the investigation of long-chain compounds with special reference to oils and fats and their derivatives; and research on synthetic resins and raw materials for the resins and plastics industry.

Sugar-cane wax

The examination of solvents for separating the useful hard wax fraction from crude cane wax has shown that, of the single solvents, *iso*propanol and acetone were most satisfactory from the combined technical and economic aspects. The first of these is not produced in Australia, and the second has the disadvantage that it is satisfactory only when used under pressure.

These considerations suggested that the obvious disadvantages in the use of a solvent mixture might be outweighed if both constituents were readily available. It has been found that certain mixtures of ethanol with either benzene or a petroleum fraction can be used at atmospheric pressure to isolate a hard wax fraction. Unlike the crude wax, the hard wax obtained responds well to bleaching with small amounts of charcoal and to oxidation of coloured impurities by air. Pale waxes can be prepared similar to those made with the use of *iso*propanol.

ORES AND METALS

Ore dressing

Investigations during the year at the Melbourne laboratory included work on ores of copper, cobalt, nickel, lead, tungsten, tin and gold, and on beach sands and phosphate rock.

An alternative method of separating sulphides from King Island scheelite concentrates by electrostatic separation was investigated; a plant utilising the process was later installed and is operating successfully.

Another extensive investigation almost completed is concerned with the preparation of separate concentrates of wolfram, scheelite and bismuth from a mixed concentrate from a mine in the Northern Territory. Magnetic concentration and flotation are the methods employed, and the increased revenue from the new processes seems likely to repay the cost of the plant within three years.

Investigations aiming to extend the beach sand mining industry and to improve concentrating methods continue. A detailed investigation of monazite recovery was completed, chrome-free ilmenite deposits in Western Australia examined, and a report on laboratory separators issued.

The flotation behaviour of a new type of base metal ore containing readily flotable gangue was being investigated throughout the year.

At Kalgoorlie laboratory work has been done on producing a better grade of lime from the high-grade lime sands available near Perth. A 4-in.-diam. fluid-bed reactor was constructed, and the lime sands were calcined at temperatures of 850 to 950°C. Some trouble was experienced with sinter formed from siliceous matter present in the lime sands. Carbon dioxide elimination was above 94% and, provided the temperature was kept below 900°C., sinter formation was not serious.

At Christmas Island the top layer of phosphate rock contains too much iron and aluminium for use as a raw material in the making of superphosphate, and very large quantities are being removed and stockpiled. A successful method of reducing the iron and aluminium to acceptable limits was developed, and recommendations were made for pilot-plant work.

An ilmenite concentrate assaying 55.4% titanium dioxide and less than 0.08% chromic oxide was produced from a beach sand from Wonnerup by table concentration followed by magnetic separation. A mixed garnet-rutile-zircon product was also obtained which would possibly yield clean rutile and clean zircon concentrates by electrostatic separation.

Titanium and its alloys

Alloys. With the physical metallurgy section's previous work on single-phase α- and β-solution alloys as a background, attention was directed to the strength at high temperatures of titanium-niobium alloys which are mixtures of α- and β-solutions. These alloys were not markedly stronger at elevated temperatures than is pure titanium, but the addition of aluminium, which dissolves preferentially in the α-phase, caused a significant increase in strength at temperatures up to 500°C. Attempts to improve the properties of the titanium-niobium-aluminium alloys by heat treatment were commenced.

Measurements at elevated temperatures of the internal friction and rigidity modulus of pure titanium and its alloys with aluminium, oxygen and nitrogen were used to examine a phenomenon thought to be strain-ageing. Additional indications of strain-ageing were obtained and the activation energy for the process was determined.

Reactions with oxygen. The effects of alloying elements on the oxidation of titanium were further examined. When oxidation was retarded, as occurred, for example, if the alloying element was tungsten, the ratio of oxygen in the residual metal to oxygen in the oxide scale was greater than that found in oxidised samples containing tin or iron which accelerated the oxidation. Any reduction in the total oxidation rate was attended by a high oxygen content in the metal. Titanium-tin alloys, which suffered rapid oxidation, were found to have a low oxygen content in the remaining metal, and they were coated with a scale which could be easily removed.

In all oxidised titanium alloys the layer of alloy adjacent to the oxide scale was found to be enriched in the alloying element.

(To be concluded)

CPE COST INDICES —LATEST FIGURES

Here are the two latest figures to be added to our cost indices (June 1949=100): Plant Construction Cost Index, April, **169.2**; Equipment Cost Index April, **258.7**.

COMPANY NEWS

An unusual occasion recently was the launching of a ship specifically designed for the owners, Marchon Products Ltd., to carry phosphate rock from North Africa to Whitehaven Harbour, Cumberland, which is only a mile from the Marchon Works.

Special equipment has been installed at Whitehaven to facilitate unloading and the ship can return via Europe to deliver detergent chemicals.

*

At a special ceremony recently a number of employees of Silvertown Rubber Co. Ltd. and its associated companies were presented with long-service awards by the chairman of the company, Sir Eric Miéville. The 40 recipients of these awards together represented a total of over 1,200 years' service.

*

The name of the Pennsylvania Salt Manufacturing Co. has now been changed to Pennsalt Chemicals Corp. It is pointed out that today the company is in no sense a salt manufacturing company, but in every sense a chemical company.

*

British Oxygen Gases Ltd. are to build a new oxygen compressing station at Mosley Road, Stretford, to meet the increased demands for the gas in the Manchester area.

*

It has been announced that immediate delivery of stainless-steel valves from stock can now be offered by Langley Alloys Ltd. It has recently been decided to manufacture for stock valves of various sizes and types in the Langley range of stainless steels. The range includes gate, globe and 'Y'-type valves.

*

The trading activities of the British Electro Metallurgical Co. are now being carried on under the title Union Carbide Ltd., Alloys Division. The change is one of name only and the trade mark *Bemco* will be retained.

Gemec Chemicals Co. have moved to 103 Mount Street, London, W.1, and are now known as Union Carbide Ltd., Chemicals Division.

New Books

Transport processes

In this book* the author continues the theme of unified presentation developed in his earlier book, 'Heat Transfer Phenomena.' To quote the publishers' preface (there is no preface by the author) in the present book, 'the various transport processes, electric current, flow of heat, mass and momentum etc. are given a common phenomenological description in terms of driving force, flux, resistance and rate of dissipation of energy.'

The introductory chapter deals with the meaning and significance of the transport phenomenon. These are defined as processes which take some entity from one point to another. The entity carried may or may not be a material substance. It is claimed that a closer study of the transport phenomenon may ultimately lead to the elimination of pilot plant experimentation. A later chapter, entitled 'Transport by Molecular Motion,' contains a useful summary and literature on diffusion in gases as well as liquid systems. The author also derives the condition under which it is possible to replace a whole series of coupled transport processes by a suitably defined, single, equivalent transport process. One of the final chapters, 'Chemical Similarity,' discusses the scale-up problems. Throughout the text there are extensive references to the literature.

The book assumes a sound mathematical knowledge on the part of the reader and the descriptive material is interspersed with mathematical derivations. Nonetheless, it contains a fresh and unified approach to the various aspects of chemical engineering. The material should be useful to the research worker in co-ordinating his knowledge of the various chemical processes. O. P. KHARBANDA.

**Transport Processes in Applied Chemistry*, by R. C. L. Bosworth. Pitman, London. Pp. 388, inc. index. Illus. 84s. net.

Induction and dielectric heating

The sixth in the 'Electricity and Productivity' series published by the British Electrical Development Association, this book* has been written for both technical and non-technical management executives, and is intended to show the essential simplicity of modern methods of electrical induction and dielectric heating from the production engineer's point of view.

It seeks to indicate how vital a part electricity plays in a wide range of new processes; how, with the aid of dielectric heating, new uses of synthetic materials have revolutionised the conception and design of many articles in everyday use; and how the adoption of well-chosen applications of induction heating or dielectric heating results in better factory conditions, improves the product and increases productivity.

**Induction and Dielectric Heating*, British Electrical Development Association, London, 1957. Pp. 191, inc. index. 8s. 6d.

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Technical Books,
308 Euston Road,
London, N.W.1.
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Preventing steel corrosion

Based on the investigations of the Protective Coatings (Corrosion) Sub-Committee of the British Iron and Steel Research Association, this book* is aimed at stating simply the facts concerning the best methods of protecting structural steelwork against atmospheric corrosion by means of paint, used alone or in conjunction with metal coatings. Separate chapters are devoted to surface preparation, choice of painting scheme and painting procedure, and of these three major factors it is surface preparation which, on the evidence of the sub-committee's researches, is considered by far the most important.

The book is well illustrated with photographic examples and four specific practical examples of the techniques described are given. Reference is also made to heat-resisting paints and to painting schemes for metal coatings on steel.

**Protective Painting of Structural Steel*, by F. Fancutt and J. C. Hudson. Chapman & Hall Ltd., London, 1957. Pp. 102, inc. index. Illus. 21s. net.

World News

INDIA

Manufacture of nickel sulphate from waste product

A scheme for the manufacture of nickel sulphate from the catalyst waste of hydrogenation factories has been prepared by the Small Industries Organisation of India's Ministry of Commerce and Consumer Industries for the guidance of small industrialists.

Nickel, in the form of nickel formate, is used as a catalyst for the hydrogenation of vegetable oils. The activity of the catalyst decreases after being used twice. This waste catalyst, available from the hydrogenation factories, will cater for the needs of the small-scale manufacture of nickel sulphate. As nickel-plating is being carried out on an extensive scale in India, there is a ready market for the nickel sulphate.

The scheme estimates production of 5,000 lb. of nickel sulphate from 100 cwt. of waste catalyst.

Aluminium development proposals

The Aluminium Committee has recently recommended the setting up of two new aluminium factories, one at Mettur, South India, capable of producing 10,000 tons p.a. each, and suggested that there is scope for a magnesium plant based on the magnesite resources of the Salem district. Current annual demand is about 20,000 tons, but is likely to be doubled by 1961. Present capacity is 7,500 tons and even with the expansion of the Aluminium Corporation and the projected 10,000-ton unit of the Indian Aluminium Co. at Hirakud, ingot capacity at 20,000 tons will still fall short of demand.

AUSTRALIA

New polystyrene plant

A new polystyrene plant will be completed by C.S.R. Chemicals Ltd., of Australia, by 1958 under a new agreement with the Dow Chemical Co. of the United States. The plant, which will be situated at Rhodes, N.S.W., will cost about £500,000.

NORWAY

Mining operations

Three State-owned undertakings are reported to be preparing to mine the rich deposits of sulphur pyrites at Grong (North Trondelag), where there are known to be deposits of 18 million tons and possibly large undiscovered reserves.

It is reported that deposits of titanium ore discovered at Jossingfjord, near Stavanger, are larger than was at first thought and are estimated to amount to 350 million tons. It is planned to set up an organisation to mine them with a capital of Kr. 75 million.

IRAQ

Chemical plant development plans

Ammonia Casale (Swiss) have been selected by the Iraq Development Board as consultants for a fertiliser plant at Basra with an initial capacity of 250,000 tons p.a. of ammonium sulphate. The cost of this project is put at I.D. 8 million. The consultants are also to study the export possibilities for the fertiliser.

The Development Board's Technical Section No. 3 has been authorised to study plans for the construction of a caustic soda plant, which will also produce chlorine, and for the construction of a plastics plant in which natural gas will be used.

GREAT BRITAIN

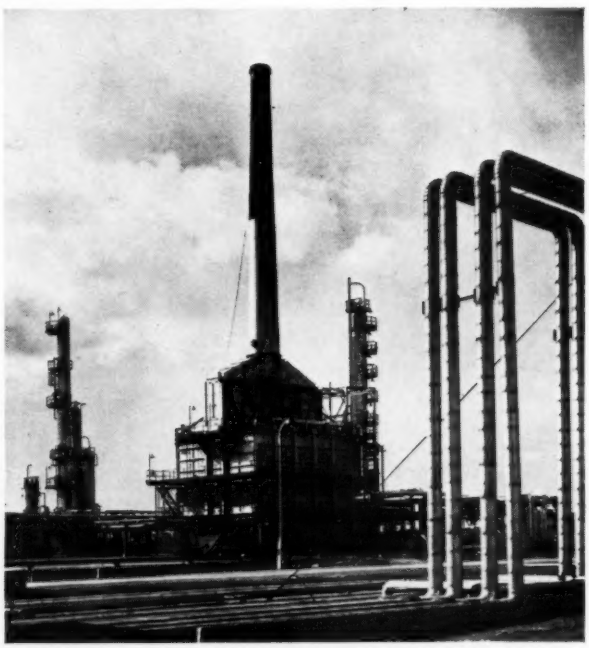
Canadian order for Q.V.F.

Q.V.F. Ltd., chemical engineers in glass and one of the Triplex group of companies, have received a £10,000 order for glass pipeline and fittings for the Polymer Corp. at Sarnia from the Meade Laboratories, Richmond Hill, Ontario.

It is the first time such a large consignment of glass pipeline has been shipped from the U.K. Special containers have had to be obtained for transit of this pipeline, which, when assembled, will be $1\frac{1}{4}$ miles in length.

Industrial expansion in the North-east

Owing to the rapid expansion of industries in the North-east, British Oxygen Gases Ltd. are building a new factory at Grangetown, Middlesbrough, at an estimated cost of £$1\frac{3}{4}$ million.



CORYTON'S CATALYTIC REFORMER COMMISSIONED

The catalytic reforming unit at Mobil's Coryton refinery, brought into operation recently, is designed to improve the quality of high-octane petrol. It was completed last autumn, but was left standing idle because of the Suez crisis and the resulting uncertainty of crude supplies which led to the rationing of products. The unit is designed to process 6,000 bbl./day of low-octane naphtha. It consists essentially of a pretreater for the removal of sulphur followed by three reactors in series containing a platinum catalyst.

The new plant, which has been built by British Oxygen Engineering Ltd., will produce compressed and liquid oxygen and liquid and tonnage nitrogen (which will be fed, after purification, by pipeline to the I.C.I. factory at Wilton). A plant capable of producing 200 tons/day of gaseous oxygen will also come into operation at a later date. Other industrial gases manufactured by the company will also be distributed from Grangetown.

The activities of the British Oxygen factory at Billingham have been transferred to the new site, which comprises 20 acres.

British-designed plastics plant for Poland

The order for the design of a large-scale polystyrene plant in Poland has been awarded to Petrocarbon Developments Ltd. The process employed is that originally engineered by Petrocarbon for Styrene Products Ltd., an associate of Shell Chemical Co. Ltd., and for an installation in France owned by the Pechiney group. The new plant will incorporate the latest operating experiences of Styrene Products Ltd.

The value of services and equipment supplied from this country will be approximately £350,000; in addition, a substantial portion of the equipment will be manufactured locally.

I.C.I. extensions in Lancashire

The Plastics Division of Imperial Chemical Industries Ltd. have agreed to terms for the purchase of a site of approximately 90 acres on the northern outskirts of Darwen, Lancashire. The purchase is subject to planning approval being obtained for the use of the land for industrial purposes.

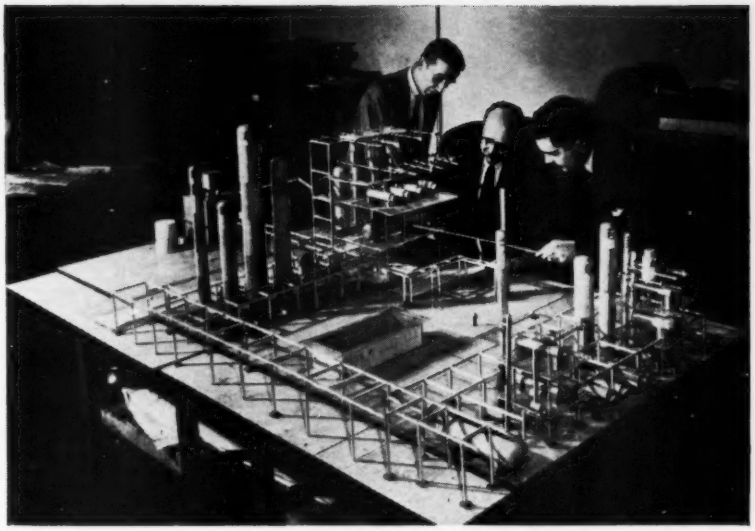
So far I.C.I.'s manufacture in Darwen has been confined to *Perspex* acrylic sheet and allied products. It is the company's intention to develop the new site for a wider range of products, and the first plant to be erected will probably be for the manufacture of *Melinex* polyester film. Later the land may be used for a further extension of *Perspex* production.

Melinex has many applications in the electrical and packaging fields. It is chemically similar to *Terylene* polyester fibre.

ISRAEL

Negev phosphate exploitation

The establishment of an I.L. 2 million calcination plant for the enrichment of Negev phosphate was among the recommendations of the Technological Advisory Board at its first meeting. The Board, established jointly by the Ministry of Development and the United Nations Technical Assistance Administration, includes a number of distinguished foreign advisers.



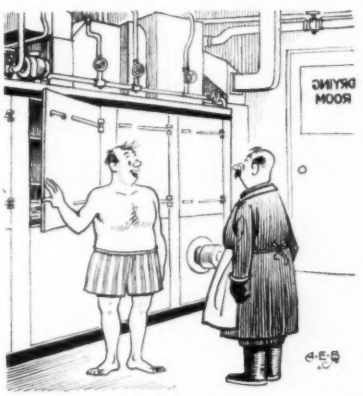
ETHYLENE OXIDE PLANTS

This picture will have an added interest for those who read our article on scale models last month. Here, an engineer of the Lummus Co. points out a model of a new ethylene oxide plant which is being built for Wyandotte Chemical Corportation at Geismar, La., near Baton Rouge. Lummus are building three such plants, each with a capacity of 60 million lb. p.a., which will utilise, for the first time on a commercial scale, the Shell Development Co.'s direct oxidation process for the production of ethylene oxide. The other two plants will be built for the Calcasieu Chemical Corporation installation at Lake Charles, La., and at Partington, England, for Petroleum Chemicals Ltd., one of the Royal Dutch/Shell group companies.

UNITED STATES

'Teflon' production to be doubled

The Dupont Co. will expand *Teflon* production facilities in a programme which will eventually more than double capacity. This major expansion of the company's Washington works in Parkersburg, West Virginia, is expected to meet rising demand for corrosion-resistant flexible tubing and insulation for high-temperature wiring made from *Teflon* fluorocarbon resins.



"I GOT SOAKED COMING TO WORK THIS MORNING"

A plant will also be built to produce *Teflon* 100-*X* perfluorocarbon resin, an experimental product which can be extruded in standard rather than special equipment. Dupont expects to have it in commercial production early in 1959 if current engineering studies are successful.

The new product is expected to have applications previously not attempted because of processing difficulties. This may result in wider use of fluorocarbon resins for such items as jackets for coaxial and multi-conductor cable, aircraft and industrial wiring, and liners and packaging for corrosive materials.

New lime plant for Nevada

United States Lime Products Corp., a subsidiary of Flintkote Co., will construct a new plant on its property at Arrowlime, Nevada, some 19 miles north-west of Las Vegas, for manufacture of oxygen steel-making lime flux. The new plant will have a capacity exceeding 400 tons/day of lime products.

The firm said the increase in pro-

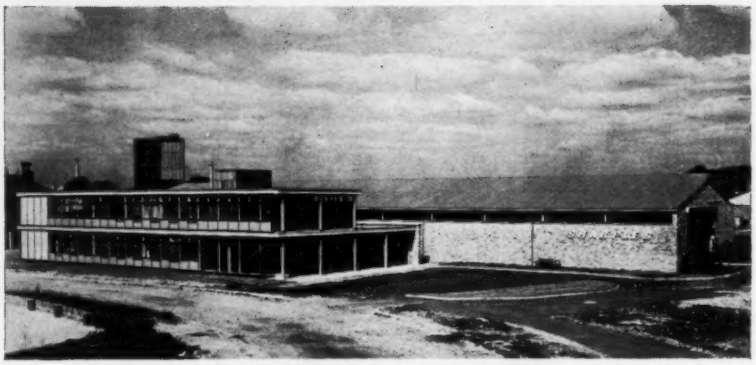
duction capacity was occasioned largely by the rapidly expanding steel industry in Southern California. A substantial part of the new facility's output would be shipped to the Kaiser Steel Corp. at Fontana, California, for use in Kaiser's new oxygen steel-making furnaces, now under construction.

The deposits at Arrowlime are among the largest known deposits of chemical and metallurgical-type limestone in the western United States.

NIGERIA

New soap factory

A new £350,000 soap factory capable of producing 5,000 tons p.a. of soap has been opened in Aba, Eastern Nigeria. This factory is owned by Algabon Industries, a subsidiary of Paterson Zochonis & Co. Ltd., and will derive most of the raw material for production from the Eastern Region.



NEW SHARPLES FACTORY OPENED

A view of the new head office and works of Sharples Centrifuges Ltd. at Tower Works, Doman Road, Camberley, Surrey, officially opened on June 14. Within the factory area are a pilot plant, laboratory and test bay linked with a glass-enclosed tower, designed to take special tanks used for development purposes. The factory floor includes a machine-shop, with such equipment as 100-mm. spindle Forges-Gilly horizontal borer, a Swift lathe with a capacity of 54 in. × 18 in., a 6-ft. radius arm Asquith radial drill, etc. The sheet-metal shop is provided with equipment for water-cooled *Argonarc* welding of stainless steel, and is complete with high-speed band saw, rolling equipment, folding equipment etc. The new works will accommodate the production, planning, technical and sales divisions of the company

INDUSTRY REPORTS . . .

Synthetic rubber plant

The whole project of the International Synthetic Rubber Co. Ltd. at Hythe, Hampshire, should be completed in the latter part of next year, Mr. G. E. Beharrell, chairman, told the shareholders at their annual general meeting in London.

The plant is being erected on a 54-acre site rented from the Esso Petroleum Co. Ltd. and adjacent to the plant which that company is erecting for the production of butadiene, their principal raw material. Procurement of plant and equipment is proceeding satisfactorily. By the end of the year £3 million will probably have been spent on the project.

Italian chemical industry progress

The annual report of the Montecatini Co. (Italy) states that progress in the chemical industry was satisfactory, especially in those branches which are traditionally the concern of Montecatini: sulphuric acid, phosphatic fertilisers, nitrogen, chemical products for industry, fungicides and insecticides, paints and varnishes, and pharmaceutical products. There was also a marked increase in the output of plastics, and a similar rise was achieved in the production of polyamide fibres. In particular, further successes were scored in the sales of *Nailon* and *Terital*.

In the sector of hydrocarbons and their derivatives the report mentions the polymerisation of olefines, work on which has now started on an industrial scale. This is a field which has been opened up to the chemical industry by the researches, based on original processes, which have been carried out by Montecatini. Work continued in 1956 on the erection at the Ferrara Works of the new plant for the production of one of these new products: polypropylene, a new plastic material which has been given the name of *Moplen*.

Chemical fertilisers

The firm of Amoniaco Portugues, S.A.R.L. (Portugal), reporting progress in 1956, records that the unusually high rainfall enabled the hydroelectric companies to supply the electro-chemical industry with power for a longer period than usual, and in 358 working days the company was able to produce 42,684 tons of ammonium sulphate, as against 35,197 tons in 1955. As the hydroelectric production of the country expands it is intended to expand the production of fertilisers by electrochemical processes, and it is hoped that with ample continuous supplies of electricity the company will be able to supply all kinds of nitrogenous fertilisers to Portuguese agriculture at lower prices. The company has already ordered equipment for the production of ammonia chemically by the extraction of hydrogen from heavy petroleum by the Koppers Totzek process, and when this is working, by the end of 1958, hopes to produce 70,000 tons of ammonium sulphate p.a. Authority has also been obtained to set up a plant subsequently for the production of ammonium nitrates and is being sought for the manufacture of 50 tons/day of urea.

Australian mining operations

Plans for the erection of a zinc smelter by Sulphide Corp. Pty. Ltd. at their Cockle Creek plant near Newcastle, New South Wales, were referred to in the chairman's statement to the parent company, the Consolidated Zinc Corp. Ltd. The plant will have a capacity of 47,000 tons p.a. of zinc. The fulfilment of the project has become possible as a result of the development of the imperial smelting process which will be used in the new smelter. The acid made available by this extension will be produced from sulphur gases from sintering operations.

In the field of lead smelting it is reported that the Port Pirie smelter of the Broken Hill Associated Smelters Pty. Ltd. again achieved excellent results in the treatment of concentrates from the Broken Hill field. Operations at the new lead concentrate sintering plant and production of sulphuric acid from the gases have continued to be highly successful.